Global Search for New Physics in 2 fb^{-1} at CDF

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SUSY 2008
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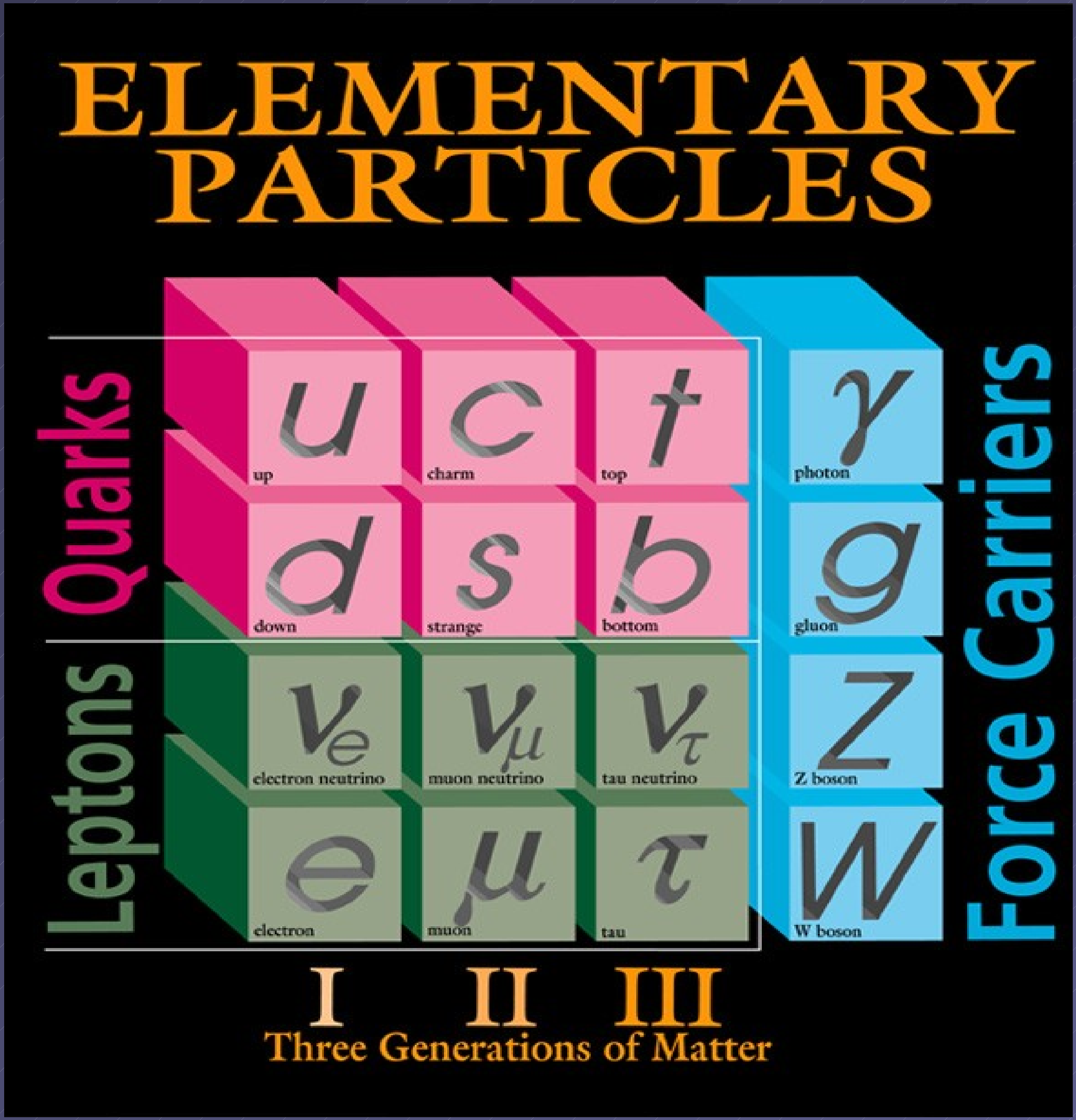
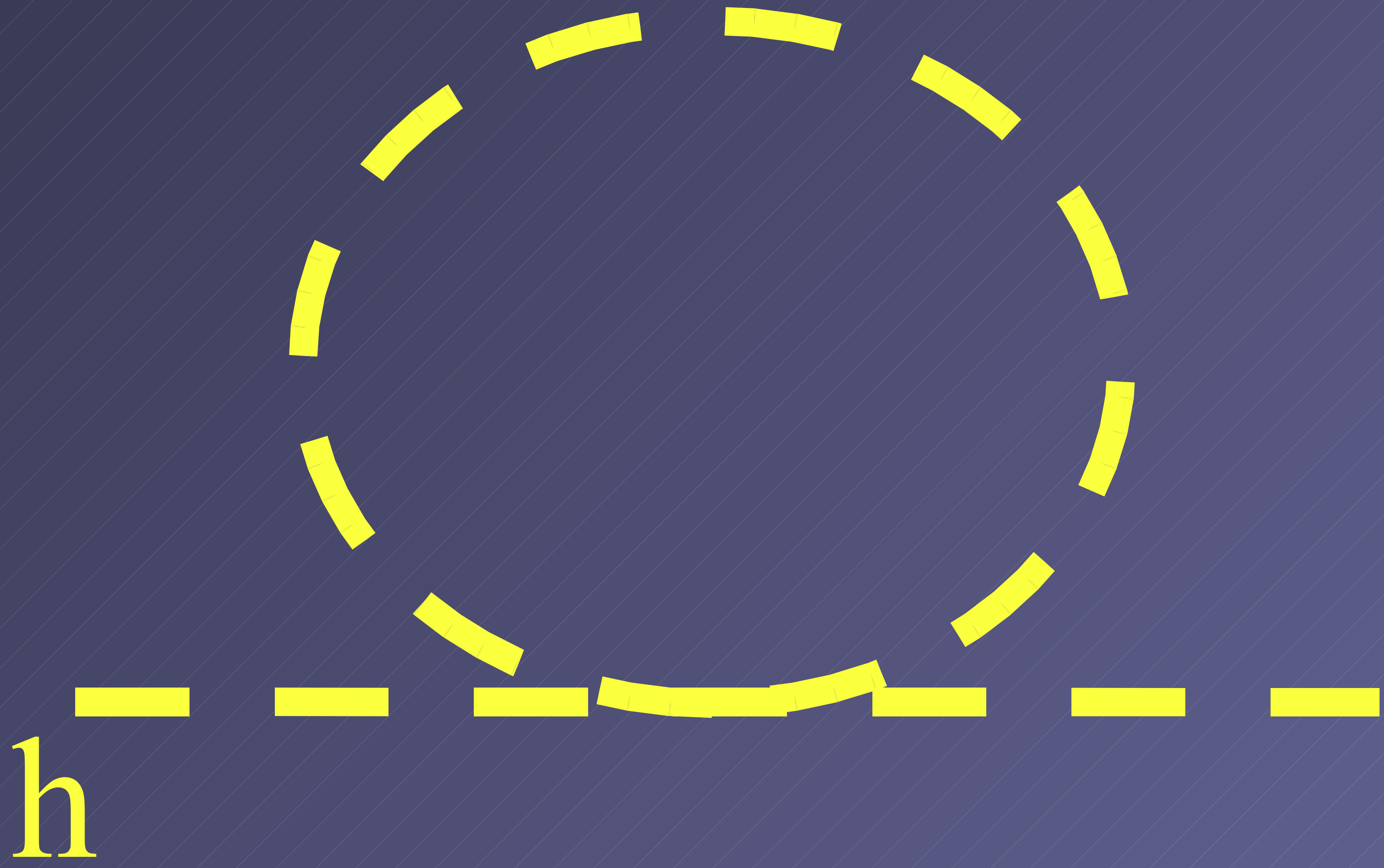
Standard Model Works Very Well

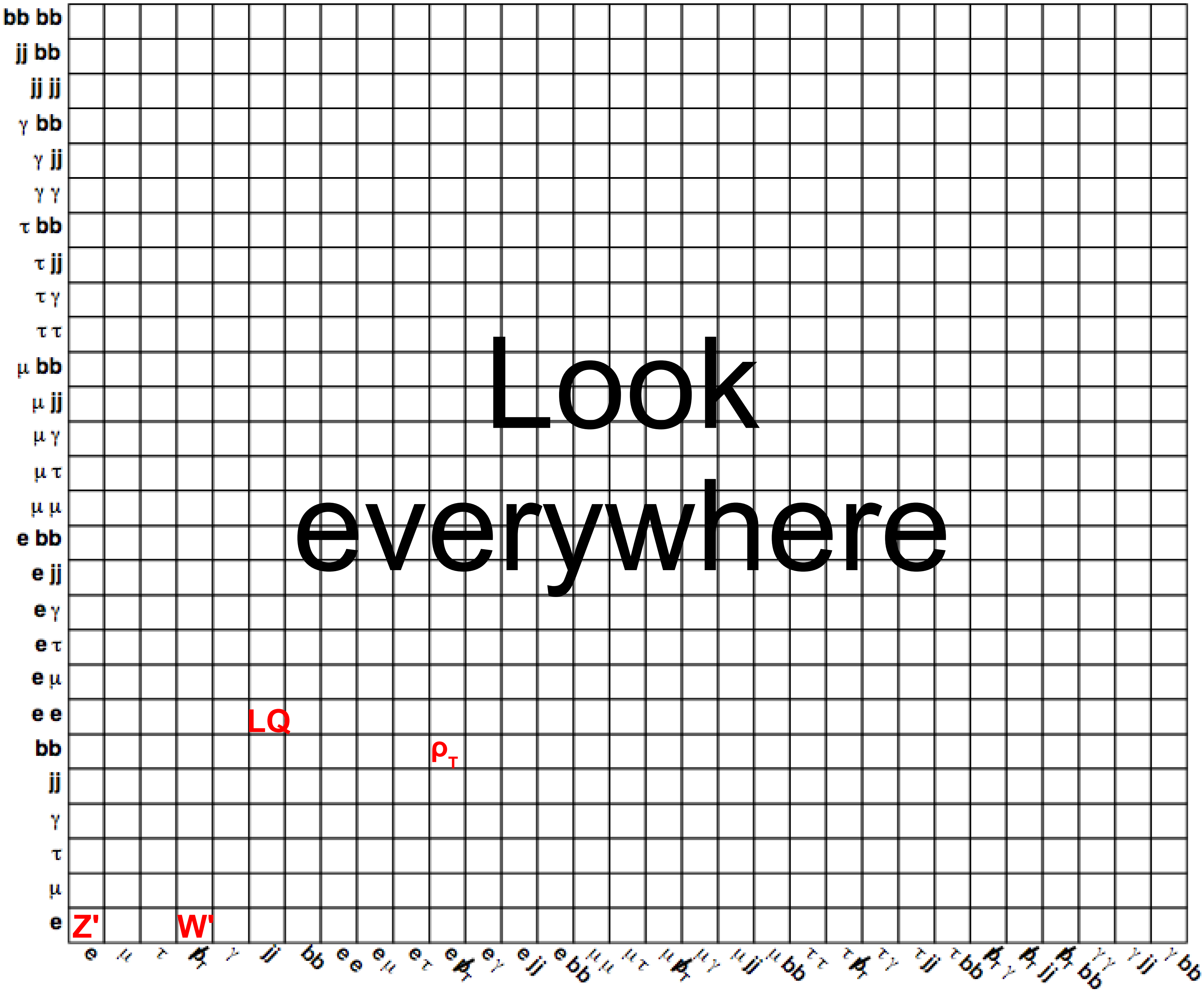


We expect something new !




bosonic TC
composite Higgs
TC-TC
hypercolor
supercolor
techni-GIM
extended TC
NOT YET THOUGHT OF
pseudo NGB
6th gen
5th gen
4th gen
vector-like family
lepto quark
sterile ν
heavy Majorana
fractionally charged
milli-charged
S,T,U
MSSM
NMSSM
effective SUSY
shadow matter
mirror symmetry
triplet Higgs
doubly charged Higgs
general 2HDSM
Type 2
Type II
spontaneous CP
superweak
milli-weak
Majoron
axion
familon
NGB
Weinberg's 3HD
quintessence
composite W, Z
contact int.
string
IIB
IIA
Extra dim
worm-hole
NOT THOUGHT

Look everywhere



Strategy Overview

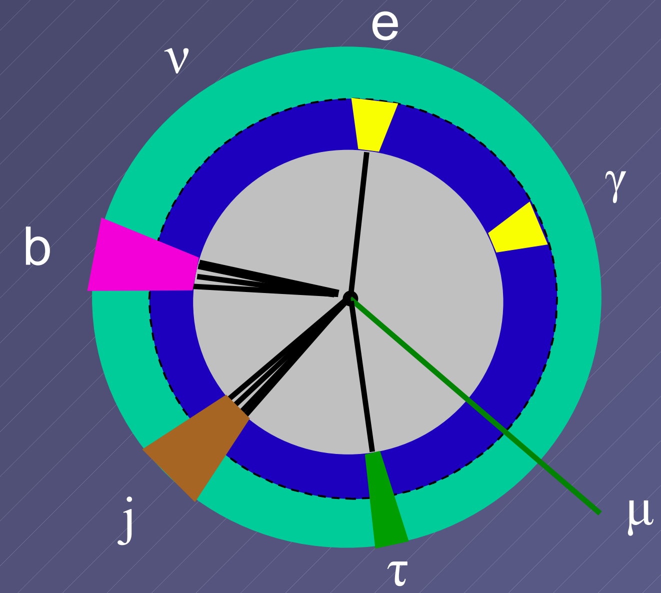
- Analyze as many data events as computing ability allows
- Construct global Standard Model background prediction
- Search for discrepancies between data and standard model prediction
- Focus attention on outliers (“5σ effects”) !!!

For reference the method is described in detail here:
arXiv:0712.1311 accepted by Phys Rev D

Identify Objects and Select Events

- Identify Physics Objects

$\boxed{p_T > 17\text{GeV}}$

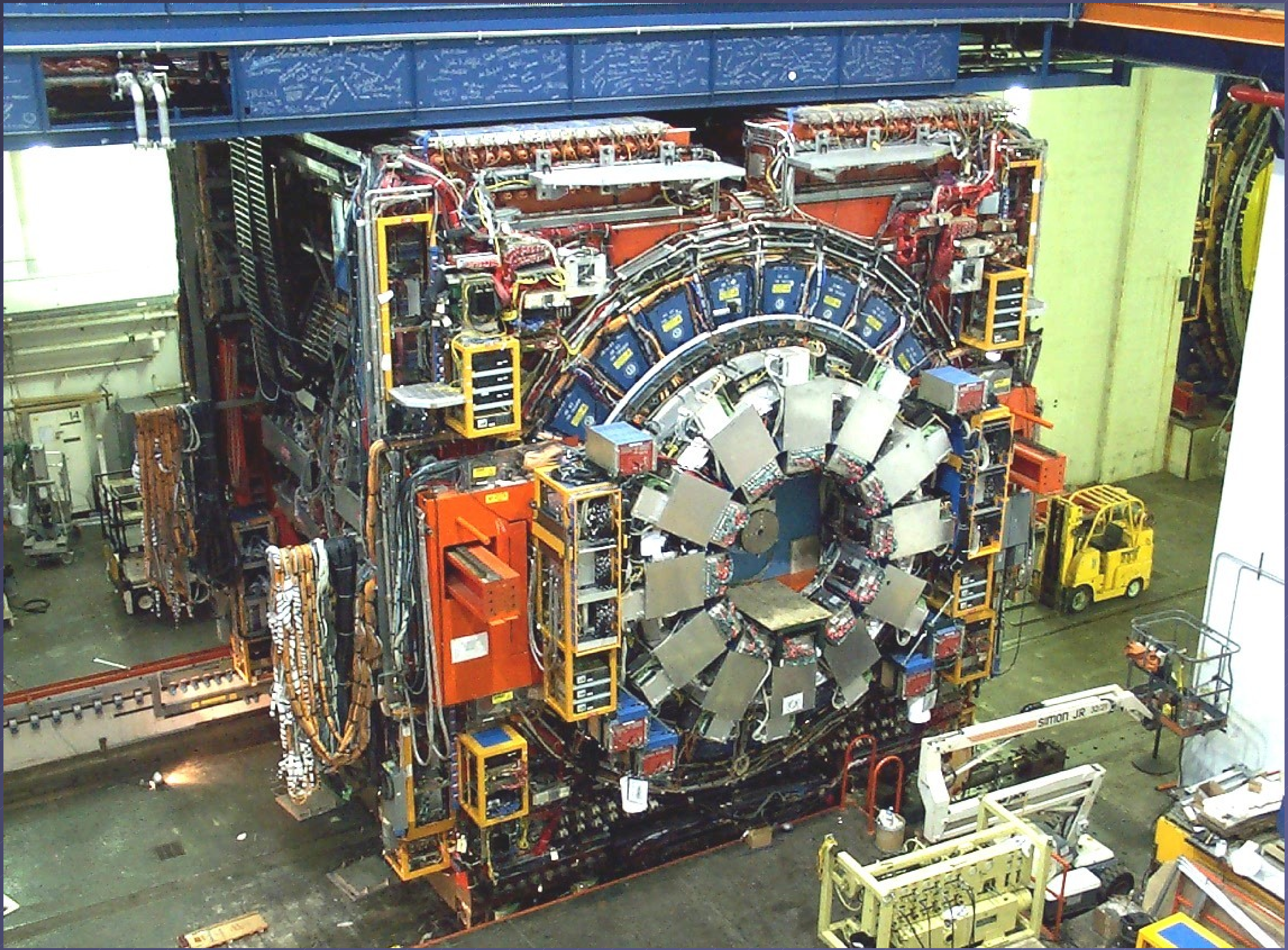


- Select Events of Interest
  - Select events containing high-p_T objects, diobjects, multi-objects
  - Total Selection of ~4 million events

Full Tevatron Standard Model Monte Carlo Set

Dataset	Process	Weights *	Number =	Total weight					
pyth_jj_000	Pythia jj 0<pT<10	1100	2	2113.78	ut0s2w	Alpgen W(-> tau v)+jets	0.29	5220	1534.87
pyth_jj_010	Pythia jj 10<pT<18	500	57	28500	mad_vtvt-a	MadEvent Z(->vv) gamma	0.27	138	37.48
pyth_pj_008	Pythia j gamma 8<pT<12	87	5	434.31	mad_veve-a	MadEvent Z(->vv) gamma	0.27	139	37.39
mrenna_mu+mu-	MadEvent Z(-> mu mu)	30	219	6474.94	we0s9t	Pythia W(-> tau v)	0.26	66004	17092.3
pyth_jj_090	Pythia jj 90<pT<120	22	2085	45680.5	ut0swi	Alpgen W(-> tau v)+jets	0.24	27810	6632.37
pyth_pj_012	Pythia j gamma 12<pT<22	21	1974	42110.7	pyth_pp	Pythia gamma gamma	0.23	25786	5807.24
pyth_jj_018	Pythia jj 18<pT<40	19	23398	450480	zeis6d	Pythia Z(->ee)	0.22	484911	106271
mad_vtvt-j	MadEvent Z(->vv) j	16	2	31.86	mad_e+e-b-b	MadEvent Z(->ee) bb	0.22	1031	224.6
mad_veve-j	MadEvent Z(->vv) j	16	2	31.69	re0s28	Baur W(->ev) gamma	0.21	22076	4701.49
alpgen_eve	Alpgen W(->e v)	12	5823	68289.9	alpgen_evejj	Alpgen W(->e v) jj	0.21	175607	37356.5
mrenna_e+e-	MadEvent Z(->ee)	10	5974	60159.9	alpgen_muvmjj	Alpgen W(-> mu v) jj	0.2	112548	22156.7
alpgen_muvm	Alpgen W(-> mu v)	9.9	4483	44213.5	ztopcz	Pythia ZZ	0.19	583	109.58
pyth_jj_120	Pythia jj 120<pT<150	8.3	3282	27170.8	stelzer_Zaj	stelzer_Zaj	0.18	1585	286.94
pyth_jj_060	Pythia jj 60<pT<90	6.7	25299	170363	mad_aajj	MadEvent jj gamma gamma	0.18	7872	1415.27
mrenna_mu+mu-j	MadEvent Z(-> mu mu) j	6.6	3211	21126	mad_mu+mu-b-b	MadEvent Z(-> mu mu) bb	0.18	619	108.52
pyth_jj_040	Pythia jj 40<pT<60	5	88450	438739	mad_e+e-jj	MadEvent Z(->ee) jj	0.17	773	133.82
pyth_bj_010	Pythia bj 10<pT<18	3.6	167	604.26	re0s29	Baur W(-> mu v) gamma	0.17	19999	3461.88
pyth_jj_200	Pythia jj 200<pT<300	3.4	72998	249296	re0sia	Baur W(-> tau v) gamma	0.17	2837	468.24
mad_veve-a_f	MadEvent Z(->vv) gamma	3.4	13	44.23	mad_veve-j_f	MadEvent Z(->vv) j	0.16	14	2.21
ut0sw0	Alpgen W(-> tau v)+jets	3.2	649	2083.08	pyth_jj_300	Pythia jj 300<pT<400	0.14	103806	14875.4
pyth_pj_022	Pythia j gamma 22<pT<45	3	31308	94944	mad_aaa_f	MadEvent gamma gamma gamma	0.14	55	7.59
pyth_jj_150	Pythia jj 150<pT<200	2.7	59222	162273	cosmic_j_hi	Cosmic (jet100)	0.12	36667	4484.23
we0sfe	Pythia W(->e v)	2.4	381176	920761	pyth_bj_040	Pythia bj 40<pT<60	0.12	161606	18764.2
cosmic_j_lo	Cosmic (jet20)	2.3	122	276.85	mrenna_e+e-jjj	MadEvent Z(->ee) jjj	0.11	23968	2661.32
cosmic_ph	Cosmic (photon_25_iso)	1.8	2700	4892.78	ze0s8t	Pythia Z(-> tau tau)	0.092	16278	1496.71
pyth_pj_080	Pythia j gamma 80<pT	1.5	18464	28033.3	pyth_bj_200	Pythia bj 200<pT<300	0.081	252357	20555.5
mrenna_e+e-j	MadEvent Z(->ee) j	1.4	28137	40761	hewk03	MadEvent Z(->ee) gamma	0.081	70511	5713.41
pyth_pj_045	Pythia j gamma 45<pT<80	1.4	83370	117889	mad_aaa	MadEvent gamma gamma gamma	0.079	72	5.69
mrenna_mu+mu-jj	MadEvent Z(-> mu mu) jj	1.3	4150	5503.82	zx0sem	Pythia Z(-> mu mu) (m_Z<20)	0.075	30	2.26
pyth_bj_018	Pythia bj 18<pT<40	1.1	16076	18233.3	wenubb0p	Alpgen W(->e v) bb	0.075	41332	3096.21
mad_e+e-	MadEvent Z(->ee)	1	522	542.22	wmnubb0p	Alpgen W(-> mu v) bb	0.075	25998	1946.94
stelzer_l+l-j	stelzer_l+l-j	0.92	665	611.86	zx0see	Pythia Z(->ee) (m_Z<20)	0.074	79	5.85
mrenna_e+e-jj	MadEvent Z(->ee) jj	0.91	11292	10317.9	overlay	Overlaid events	0.073	11443	837.38
mad_mu+mu-	MadEvent Z(-> mu mu)	0.88	83	73.28	wenubb1p	Alpgen W(->e v) bb j	0.072	14076	1018.56
pyth_bj_060	Pythia bj 60<pT<90	0.87	10711	9307.8	wmnubb1p	Alpgen W(-> mu v) bb j	0.072	8420	608.96
mad_vtvt-a_f	MadEvent Z(->vv) gamma	0.85	38	32.2	hewk04	MadEvent Z(-> mu mu) gamma	0.072	2034	145.66
pyth_bj_090	Pythia bj 90<pT<120	0.83	2385	1985.66	pyth_jj_400	Pythia jj 400<pT	0.068	13106	890.33
mad_vtvt-j_f	MadEvent Z(->vv) j	0.71	7	4.94	alpgen_evejjj	Alpgen W(->e v) jjj	0.068	92568	6259.88
stelzer_Waj	MadEvent W(->l v)j gamma	0.68	1644	1125.1	alpgen_muvmjjj	Alpgen W(-> mu v) jjj	0.066	55644	3689.5
pyth_bj_120	Pythia bj 120<pT<150	0.67	2854	1904.7	ttop0z	Herwig ttbar	0.065	30649	1982.71
mad_aaj	MadEvent j gamma gamma	0.51	563	287.44	ze0sat	Pythia Z(-> tau tau)	0.063	23833	1512.59
we0s8m	Pythia W(-> mu v)	0.49	1.2908e+06	630854	ut0s3w	Alpgen W(-> tau v)+jets	0.063	4470	282.34
pyth_bj_150	Pythia bj 150<pT<200	0.44	28229	12531.9	wmnubb2p	Alpgen W(-> mu v) bb jj	0.054	3508	188.94
mrenna_mu+mu-jjj	MadEvent Z(-> mu mu) jjj	0.44	3448	1500.61	wenubb2p	Alpgen W(->e v) bb jj	0.054	6044	323.72
mad_e+e-j	MadEvent Z(->ee) j	0.39	733	285.76	we0scd	Pythia WZ	0.053	2910	154.95
alpgen_evej	Alpgen W(->e v) j	0.35	398712	140667	we0sgd	Pythia WW	0.048	2563	122.77
we0sat	Pythia W(-> tau v)	0.35	49498	17125.5	we0sbd	Pythia WW	0.048	2843	136.03
mad_mu+mu-j	MadEvent Z(-> mu mu) j	0.34	495	166.31	alpgen_evejjjj	Alpgen W(->e v) jjjj	0.027	41589	1118.82
mad_mu+mu-jj	MadEvent Z(-> mu mu) jj	0.32	1682	531.82	alpgen_muvmjjjj	Alpgen W(-> mu v) jjjj	0.024	26964	659.93
zeis9m	Pythia Z(-> mu mu)	0.3	371008	110522	ut0s4w	Alpgen W(-> tau v)+jets	0.023	2488	57.06
alpgen_muvmj	Alpgen W(-> mu v) j	0.3	281049	83604.3	Total:				4.37683e+06

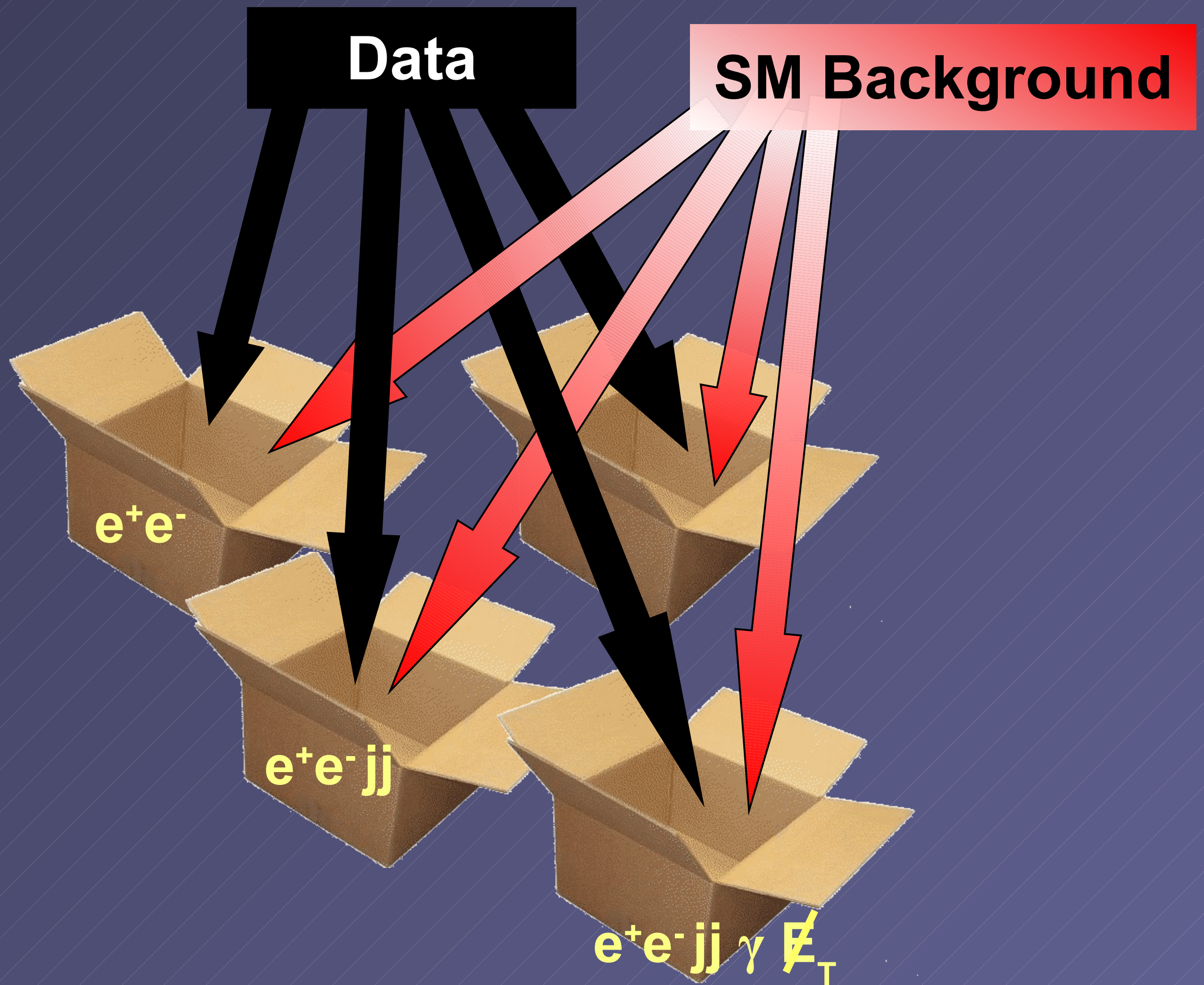
Simulate detector response



Correction Model

- Attempts to accurately reflect the limit to our systematic understanding of the detector and the standard model
- Correction factors include: integrated luminosity, k-factors, trigger efficiencies, reconstruction efficiencies, fake rates
- Values are obtained by a global fit of data to background yielding a set of values maximizing global agreement

Partition Events into **exclusive final states**



Global Comparison

399 Final State Populations

CDF Run II Preliminary (2.0 fb^{-1})
The calculation of σ accounts for the trials factor

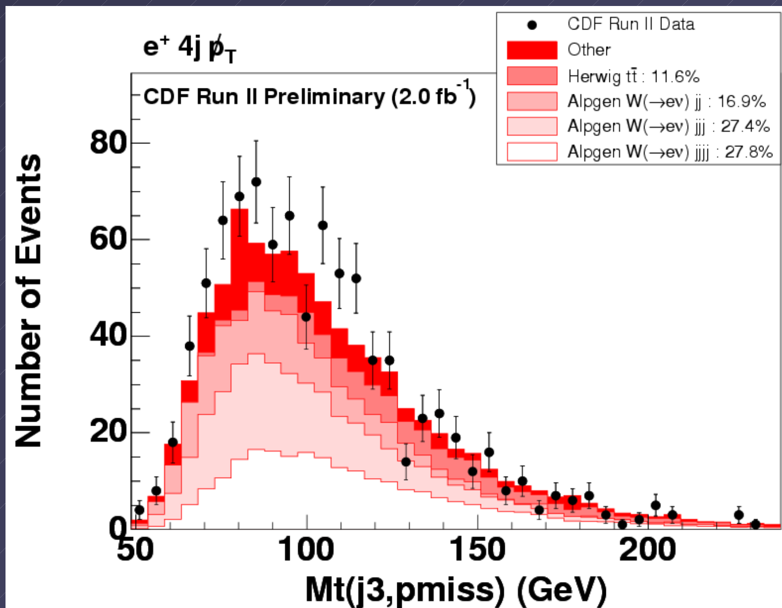
Final State	Data	Background
$be^{\pm}\not{p}$	690	817.7 ± 9.2
$\gamma\tau^{\pm}$	1371	1217.6 ± 13.3
$\mu^{\pm}\tau^{\pm}$	63	35.2 ± 2.8
$b2j\not{p}$ high-Σp_T	255	327.2 ± 8.9
$2j\tau^{\pm}$ low-Σp_T	574	670.3 ± 8.6
$3j\tau^{\pm}$ low-Σp_T	148	199.8 ± 5.2
$e^{\pm}\not{p}\tau^{\pm}$	36	17.2 ± 1.7
$2j\tau^{\pm}\tau^{\mp}$	33	62.1 ± 4.3
$e^{\pm}j$	741710	764832 ± 6447.
$j2\tau^{\pm}$	105	150.8 ± 6.3
$e^{\pm}2j$	256946	249148 ± 2201.
$2bj$ low-Σp_T	279	352.5 ± 11.9
$j\tau^{\pm}$ low-Σp_T	1385	1525.8 ± 15
$2b2j$ low-Σp_T	108	153.5 ± 6.8
$b\mu^{\pm}\not{p}$	528	613.5 ± 8.7
$\mu^{\pm}\gamma\not{p}$	523	611 ± 12.1
$2b\gamma$	108	70.5 ± 7.9
$8j$	14	13.1 ± 4.4
$7j$	103	97.8 ± 12.2
$6j$	653	659.7 ± 37.3
$5j$	3157	3178.7 ± 67.1
$4j$ high-Σp_T	88546	89096.6 ± 935.2
$4j$ low-Σp_T	14872	14809.6 ± 186.3
$4j2\gamma$	46	46.4 ± 3.9
$4j\tau^{\pm}$ high-Σp_T	29	26.6 ± 1.7
$4j\tau^{\pm}$ low-Σp_T	43	63.1 ± 3.3
$4j\not{p}$ high-Σp_T	1064	1012 ± 62.9
$4j\gamma\tau^{\pm}$	19	10.8 ± 2
$4j\gamma\not{p}$	62	104.2 ± 22.4
$4j\gamma$	7962	8271.2 ± 245.1
$4j\mu^{\pm}\not{p}$	574	590.5 ± 13.6
$4j\mu^{\pm}\mu^{\mp}$	38	48.4 ± 6.2
$4j\mu^{\pm}$	1363	1350.1 ± 37.7
$3j$ high-Σp_T	159926	159143 ± 1061.
$3j$ low-Σp_T	62681	64213.1 ± 496
$3j2\gamma$	151	177.5 ± 7.1
$3j\tau^{\pm}$ high-Σp_T	68	76.9 ± 3
$3j\not{p}$ high-Σp_T	1706	1899.4 ± 77.6
$3j\not{p}$ low-Σp_T	42	36.2 ± 5.7
$3j\gamma\tau^{\pm}$	39	37.8 ± 3.6
$3j\gamma\not{p}$	204	249.8 ± 24.4
$3j\gamma$	24639	24899.4 ± 372.4
$3j\mu^{\pm}\not{p}$	2884	2971.5 ± 52.1
$3j\mu^{\pm}\gamma\not{p}$	10	3.6 ± 1.9
$3j\mu^{\pm}\gamma$	15	7.9 ± 2.9
$3j\mu^{\pm}\mu^{\mp}$	175	177.8 ± 16.2
$3j\mu^{\pm}$	5032	4989.5 ± 108.9
$3b2j$	23	28.9 ± 4.7
$3bj$	82	82.6 ± 5.7
$3b$	67	85.6 ± 7.7
$2\tau^{\pm}$	498	512.7 ± 14.2
$2\gamma\not{p}$	128	107.2 ± 6.9
2γ	5548	5562.8 ± 40.5
$2j$ high-Σp_T	190773	190842 ± 781.2
$2j$ low-Σp_T	165984	162530 ± 1581
$2j2\tau^{\pm}$	22	40.6 ± 3.2
$2j2\gamma\not{p}$	11	8 ± 2.4
$2j2\gamma$	580	581 ± 13.7
$2j\tau^{\pm}$ high-Σp_T	96	114.6 ± 3.3

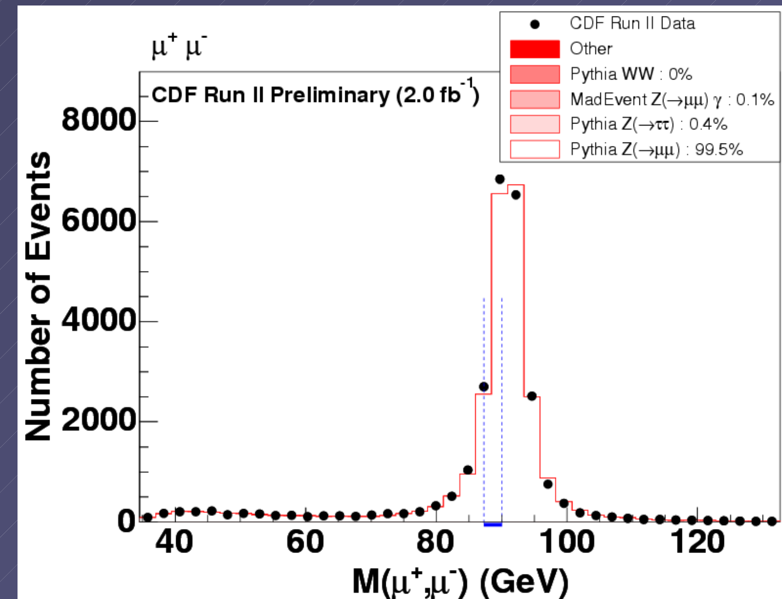
Final State	Data	Background
$2j\not{p}$ high-Σp_T	87	80.9 ± 6.8
$2j\not{p}$ low-Σp_T	114	79.5 ± 100.8
$2j\not{p}\tau^{\pm}$	18	13.2 ± 2.2
$2j\gamma\tau^{\pm}$	142	144.6 ± 5.7
$2j\gamma\not{p}$	908	980.3 ± 63.7
$2j\gamma$	71364	73021.4 ± 595.9
$2j\mu^{\pm}\tau^{\mp}$	16	19.3 ± 2.2
$2j\mu^{\pm}\not{p}$	17927	18340.6 ± 201.9
$2j\mu^{\pm}\gamma\not{p}$	31	27.7 ± 7.7
$2j\mu^{\pm}\gamma$	57	58.2 ± 13
$2j\mu^{\pm}\mu^{\mp}\not{p}$	11	7.8 ± 2.7
$2j\mu^{\pm}\mu^{\mp}$	956	924.9 ± 61.2
$2j\mu^{\pm}$	22461	23111.4 ± 366.6
$2e^{\pm}j$	14	13.8 ± 2.3
$2e^{\pm}e^{\mp}$	20	17.5 ± 1.7
$2e^{\pm}$	32	49.2 ± 3.4
$2b$ high-Σp_T	666	689 ± 9.4
$2b$ low-Σp_T	323	313.2 ± 10.3
$2b3j$ low-Σp_T	53	57.4 ± 6.5
$2b2j$ high-Σp_T	718	803.3 ± 12.7
$2b2j\not{p}$ high-Σp_T	15	21.8 ± 2.8
$2b2j\gamma$	32	39.7 ± 6.2
$2b2j\mu^{\pm}\not{p}$	14	17.3 ± 1.9
$2b2j\mu^{\pm}$	22	21.8 ± 2
$2b\mu^{\pm}\not{p}$	11	14.4 ± 2.1
$2bj$ high-Σp_T	891	967.1 ± 13.2
$2bj\not{p}$ high-Σp_T	25	31.3 ± 3.1
$2bj\gamma$	71	54.5 ± 7.1
$2bj\mu^{\pm}\not{p}$	12	10.7 ± 1.9
$2be^{\pm}2j\not{p}$	30	27.3 ± 2.2
$2be^{\pm}2j$	72	66.5 ± 2.9
$2be^{\pm}\not{p}$	22	19.1 ± 2.2
$2be^{\pm}j\not{p}$	19	19.4 ± 2.2
$2be^{\pm}j$	63	63 ± 3.4
$2be^{\pm}$	96	92.1 ± 4.1
$\tau^{\pm}\tau^{\mp}$	856	872.5 ± 19
$\gamma\not{p}$	3793	3770.7 ± 127.3
$\mu^{\pm}\tau^{\mp}$	381	440.9 ± 7.3
$\mu^{\pm}\not{p}\tau^{\mp}$	60	75.7 ± 3.4
$\mu^{\pm}\not{p}\tau^{\pm}$	15	12 ± 2
$\mu^{\pm}\not{p}$	734290	734296 ± 4897.8
$\mu^{\pm}\gamma$	475	469.8 ± 12.5
$\mu^{\pm}\mu^{\mp}\not{p}$	169	198.5 ± 8.2
$\mu^{\pm}\mu^{\mp}\gamma$	83	60 ± 3.1
$\mu^{\pm}\mu^{\mp}$	25283	25178.5 ± 86.5
$j2\gamma\not{p}$	36	30.4 ± 4.2
$j2\gamma$	1822	1813.2 ± 27.4
$j\tau^{\pm}$ high-Σp_T	52	56.2 ± 2.5
$j\tau^{\pm}\tau^{\mp}$	203	252.2 ± 8.7
$j\not{p}$ high-Σp_T	4432	4431.7 ± 45.2
$j\gamma\tau^{\pm}$	526	476 ± 9.3
$j\gamma\not{p}$	1882	1791.9 ± 72.3
$j\gamma$	103319	102124 ± 570.6
$j\mu^{\pm}\tau^{\mp}$	71	98 ± 3.9
$j\mu^{\pm}\tau^{\pm}$	15	12 ± 2
$j\mu^{\pm}\not{p}\tau^{\mp}$	26	30.8 ± 2.6
$j\mu^{\pm}\not{p}$	109081	108323 ± 707.7
$j\mu^{\pm}\gamma\not{p}$	171	171.1 ± 31
$j\mu^{\pm}\gamma$	152	190 ± 39.3

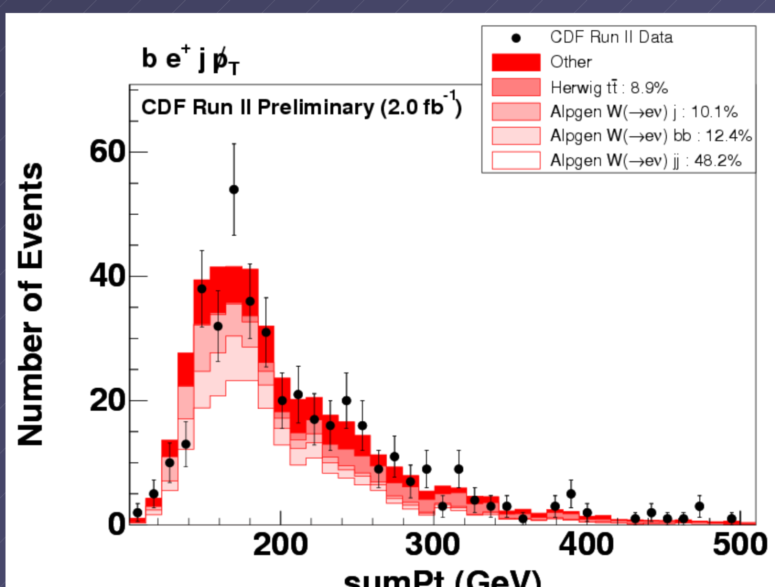
Final State	Data	Background
$j\mu^{\pm}\mu^{\mp}\not{p}$	32	32.2 ± 10.9
$j\mu^{\pm}\mu^{\mp}\gamma$	14	11.5 ± 2.6
$j\mu^{\pm}\mu^{\mp}$	4852	4271.2 ± 185.4
$j\mu^{\pm}$	77689	76987.5 ± 930.2
$e^{\pm}4j\not{p}$	903	830.6 ± 13.2
$e^{\pm}4j\gamma$	25	29.2 ± 3.6
$e^{\pm}4j$	15750	16740.4 ± 390.5
$e^{\pm}3j\tau^{\mp}$	15	21.1 ± 2.2
$e^{\pm}3j\not{p}$	4054	4077.2 ± 63.6
$e^{\pm}3j\gamma$	108	79.3 ± 5
$e^{\pm}3j$	60725	60409.3 ± 723.3
$e^{\pm}2\gamma$	41	34.2 ± 2.6
$e^{\pm}2j\tau^{\pm}$	37	47.2 ± 2.2
$e^{\pm}2j\tau^{\mp}$	109	95.9 ± 6.8
$e^{\pm}2j\not{p}$	25725	25403.1 ± 209.4
$e^{\pm}2j\gamma\not{p}$	30	31.8 ± 4.8
$e^{\pm}2j\gamma$	398	342.8 ± 15.7
$e^{\pm}2j\mu^{\mp}\not{p}$	22	14.8 ± 1.9
$e^{\pm}2j\mu^{\mp}$	23	15.8 ± 2
$e^{\pm}\tau^{\pm}$	437	387 ± 5.3
$e^{\pm}\tau^{\mp}$	1333	1266 ± 12.3
$e^{\pm}\not{p}\tau^{\mp}$	109	106.1 ± 2.7
$e^{\pm}\not{p}$	960826	956579 ± 3077.
$e^{\pm}\gamma\not{p}$	497	496.8 ± 10.3
$e^{\pm}\gamma$	3578	3589.9 ± 24.1
$e^{\pm}\mu^{\pm}\not{p}$	31	29.9 ± 1.6
$e^{\pm}\mu^{\mp}\not{p}$	109	99.4 ± 2.4
$e^{\pm}\mu^{\pm}$	45	28.5 ± 1.8
$e^{\pm}\mu^{\mp}$	350	313 ± 5.4
$e^{\pm}j2\gamma$	13	16.1 ± 3.9
$e^{\pm}j\tau^{\mp}$	386	418 ± 18.9
$e^{\pm}j\tau^{\pm}$	160	162.8 ± 3.5
$e^{\pm}j\not{p}\tau^{\mp}$	48	44.6 ± 3.3
$e^{\pm}j\not{p}\tau^{\pm}$	11	8.3 ± 1.5
$e^{\pm}j\not{p}$	121431	121023 ± 747.6
$e^{\pm}j\gamma\not{p}$	159	192.6 ± 10.9
$e^{\pm}j\gamma$	1389	1368.9 ± 38.9
$e^{\pm}j\mu^{\mp}\not{p}$	42	33 ± 2.9
$e^{\pm}j\mu^{\pm}\not{p}$	16	9.2 ± 1.9
$e^{\pm}j\mu^{\mp}$	62	63.8 ± 3.2
$e^{\pm}j\mu^{\pm}$	13	8.2 ± 2
$e^{\pm}e^{\mp}4j$	148	159.1 ± 7
$e^{\pm}e^{\mp}3j$	717	743.6 ± 24.4
$e^{\pm}e^{\mp}2j\not{p}$	32	41.4 ± 5.6
$e^{\pm}e^{\mp}2j\gamma$	10	11.4 ± 2.9
$e^{\pm}e^{\mp}2j$	3638	3566.8 ± 72
$e^{\pm}e^{\mp}\tau^{\pm}$	18	16.1 ± 1.7
$e^{\pm}e^{\mp}\not{p}$	822	831.8 ± 13.6
$e^{\pm}e^{\mp}\gamma$	191	221.9 ± 5.1
$e^{\pm}e^{\mp}j\not{p}$	155	170.8 ± 12.4
$e^{\pm}e^{\mp}j\gamma$	48	45 ± 3.9
$e^{\pm}e^{\mp}j$	17903	18258.2 ± 204.4
$e^{\pm}e^{\mp}$	98901	99086.9 ± 147.8
$b6j$	51	42.3 ± 3.8
$b5j$	237	192.5 ± 7.1
$b4j$ high-Σp_T	26	23.4 ± 2.6
$b4j$ low-Σp_T	836	821.7 ± 15.9
$b3j$ high-Σp_T	12081	12071 ± 84.1
$b3j$ low-Σp_T	2974	2873 ± 31

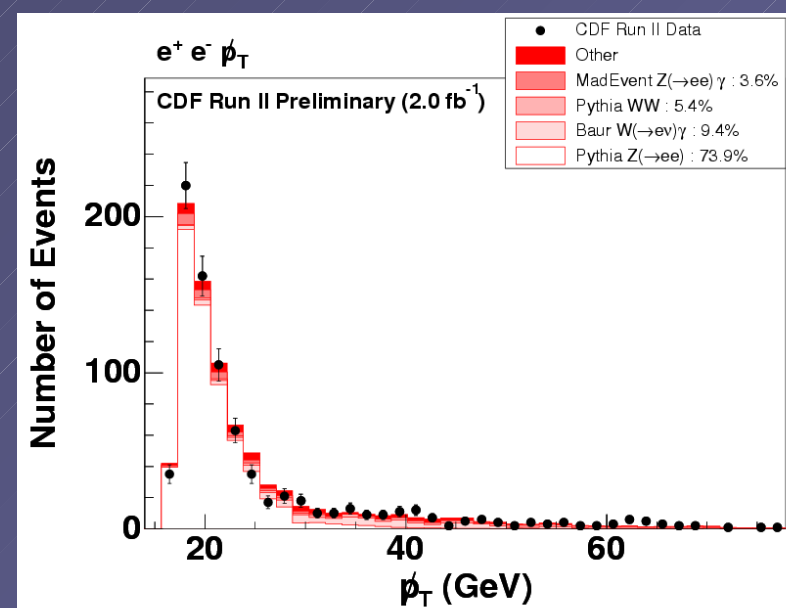
Global Comparison

19650 Kinematic Distributions



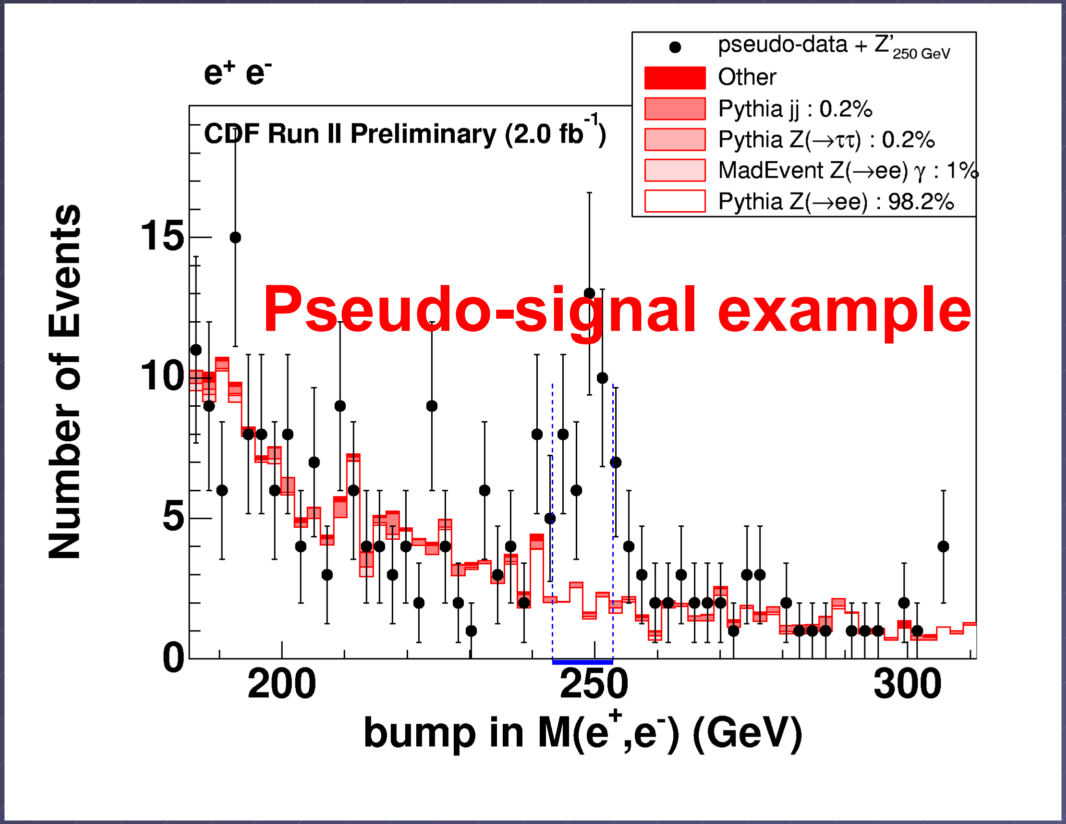






Global Comparison

Bump Hunter: 5036 Mass variables

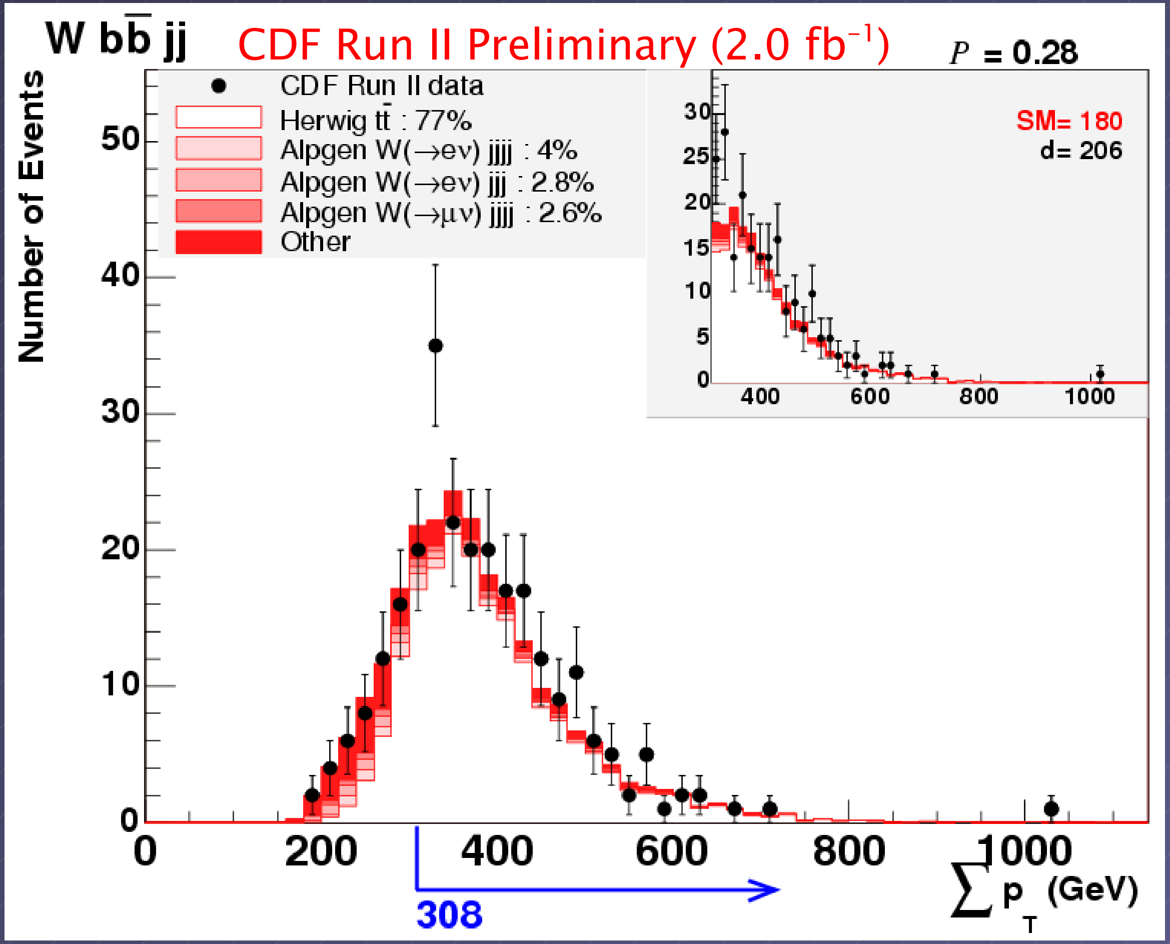


- Search for resonant production of new particles
- Look for narrow resonances in mass distributions.
- (width = detector resolution)
- Require quality criteria to eliminate erroneous bumps

Global Comparison

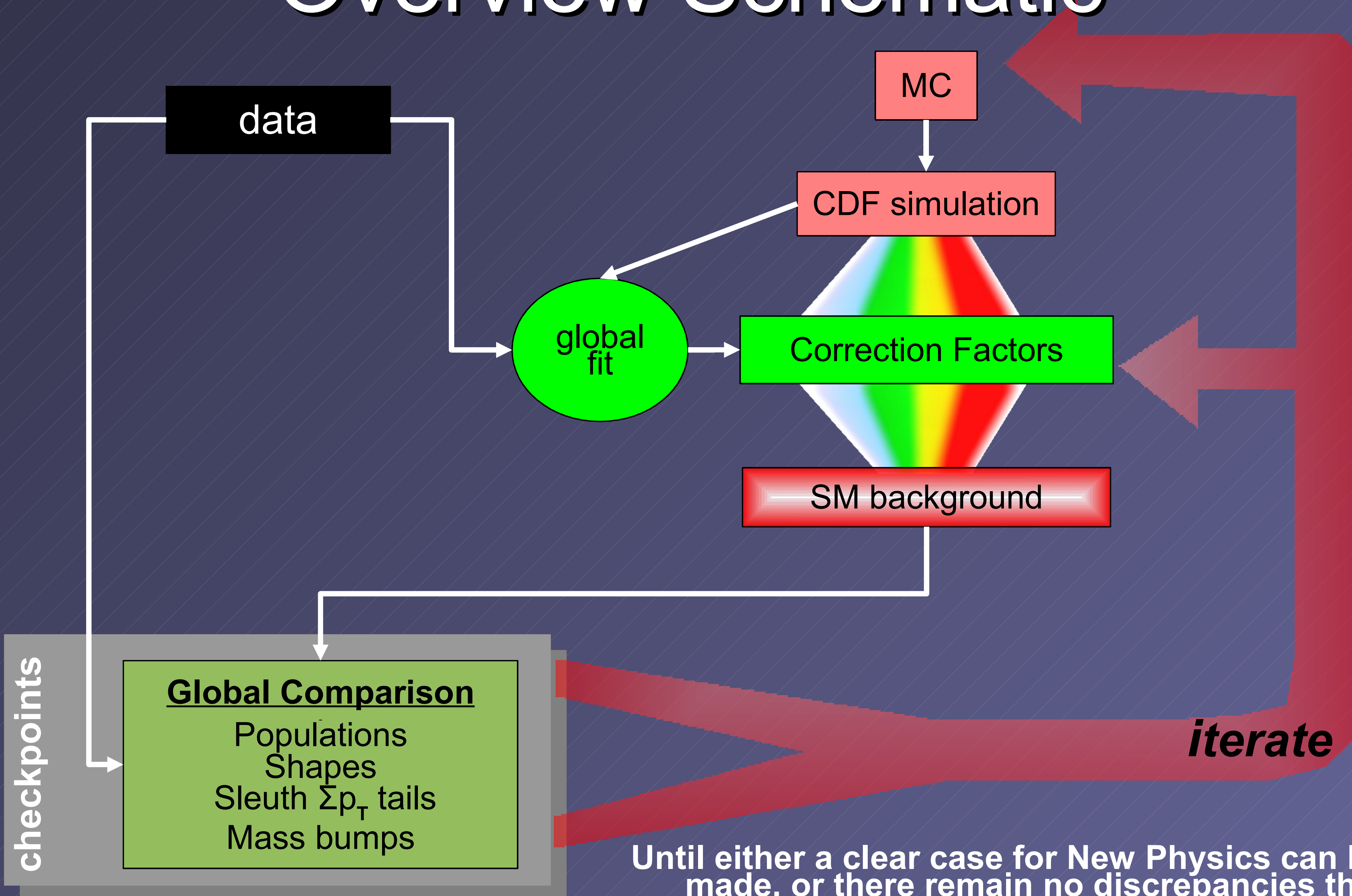
Sleuth Final States : 87

Sleuth variable: $$\sum p_T \equiv \sum_i |\vec{p}_i| + \left|\overrightarrow{\mathrm{uncl}}\right| + \left|\vec{\not{p}}\right|,$$



- Scan the ΣP_T spectrum
- Look for semi-infinite region with the most significant excess of data
- Excesses at Large ΣP_T are expected by a wide spectrum of new physics scenarios.

Overview Schematic



Until either a clear case for New Physics can be made, or there remain no discrepancies that motivate a case for New Physics

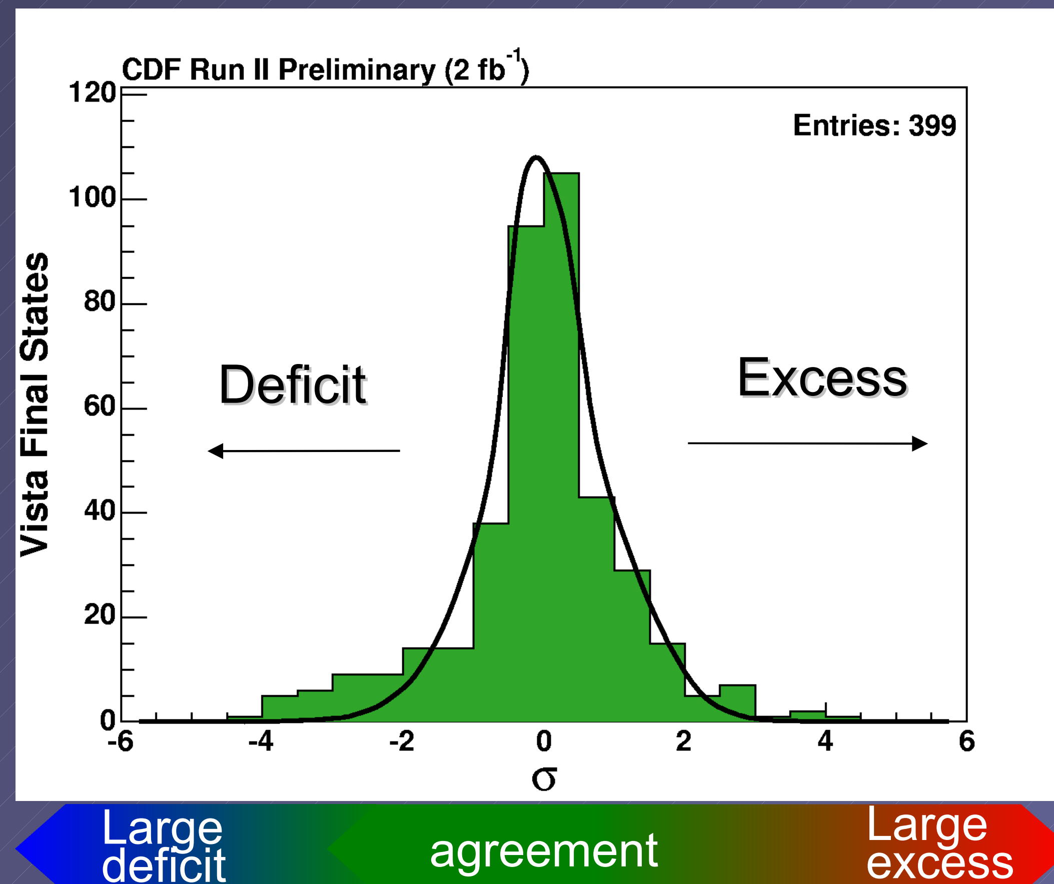
Results

Final State Populations

List of Top Population Discrepancies

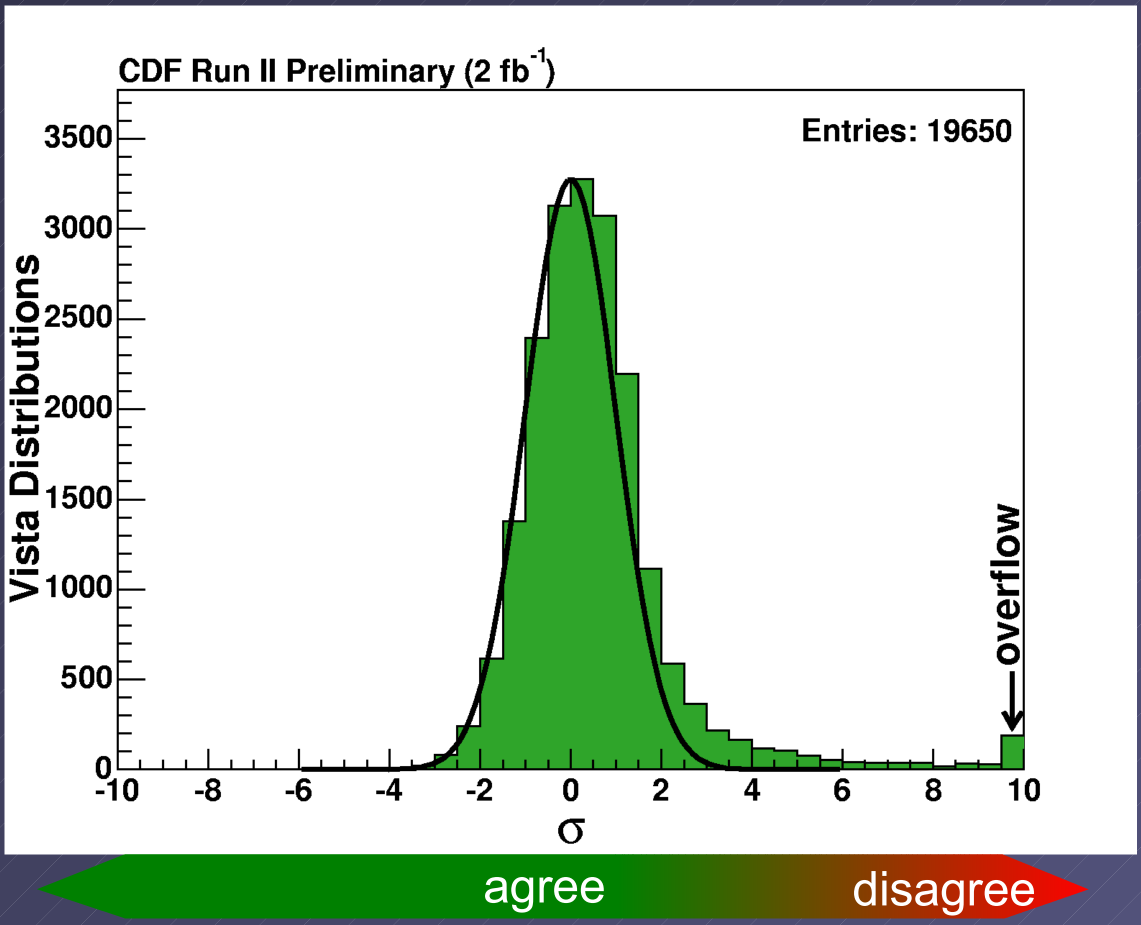
CDF Run II Preliminary (2.0 fb^{-1})
The calculation of σ accounts for the trials factor

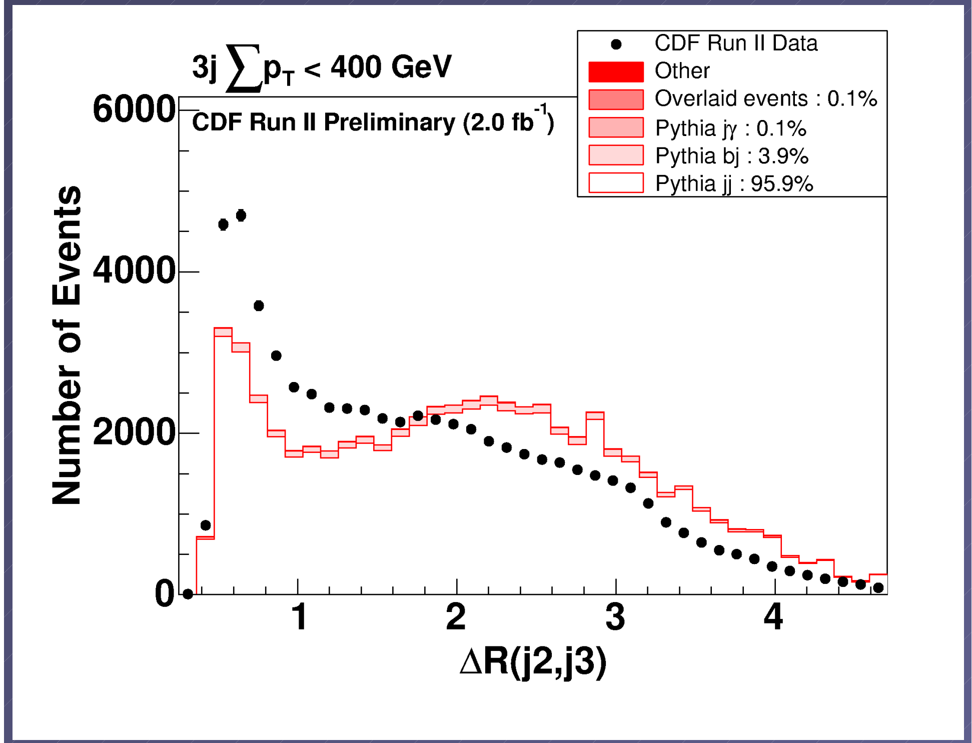
Final State	Data	Background	σ
$be^{\pm}\not{p}$	690	817.7 ± 9.2	-2.7
$\gamma\tau^{\pm}$	1371	1217.6 ± 13.3	$+2.2$
$\mu^{\pm}\tau^{\pm}$	63	35.2 ± 2.8	$+1.7$
$b2j\not{p}$ high-Σp_T	255	327.2 ± 8.9	-1.7
$2j\tau^{\pm}$ low-Σp_T	574	670.3 ± 8.6	-1.5
$3j\tau^{\pm}$ low-Σp_T	148	199.8 ± 5.2	-1.4
$e^{\pm}\not{p}\tau^{\pm}$	36	17.2 ± 1.7	$+1.4$
$2j\tau^{\pm}\tau^{\mp}$	33	62.1 ± 4.3	-1.3
$e^{\pm}j$	741710	764832 ± 6447.2	-1.3
$j2\tau^{\pm}$	105	150.8 ± 6.3	-1.2
$e^{\pm}2j$	256946	249148 ± 2201.5	$+1.2$
$2bj$ low-Σp_T	279	352.5 ± 11.9	-1.1
$j\tau^{\pm}$ low-Σp_T	1385	1525.8 ± 15	-1.1
$2b2j$ low-Σp_T	108	153.5 ± 6.8	-1
$b\mu^{\pm}\not{p}$	528	613.5 ± 8.7	-0.9
$\mu^{\pm}\gamma\not{p}$	523	611 ± 12.1	-0.8
$2b\gamma$	108	70.5 ± 7.9	$+0.1$
8j	14	13.1 ± 4.4	0
7j	103	97.8 ± 12.2	0
6j	653	659.7 ± 37.3	0
5j	3157	3178.7 ± 67.1	0



No Significant Discrepancy in Populations!

Kinematic Shapes

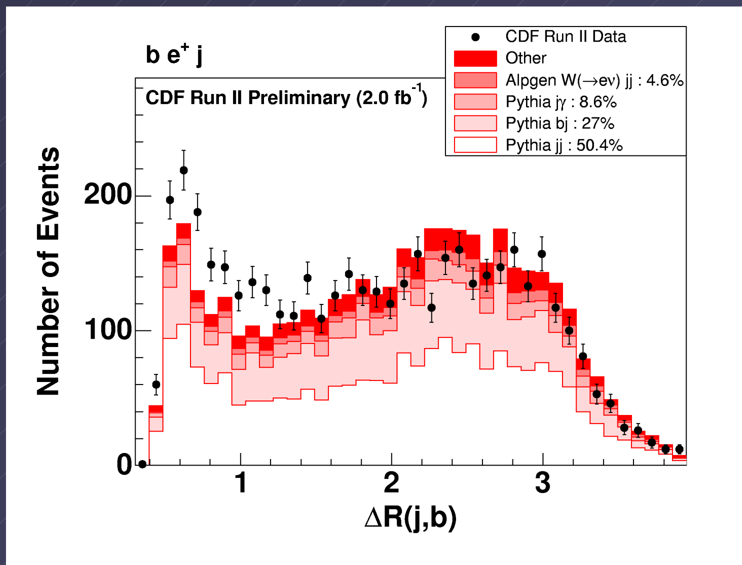


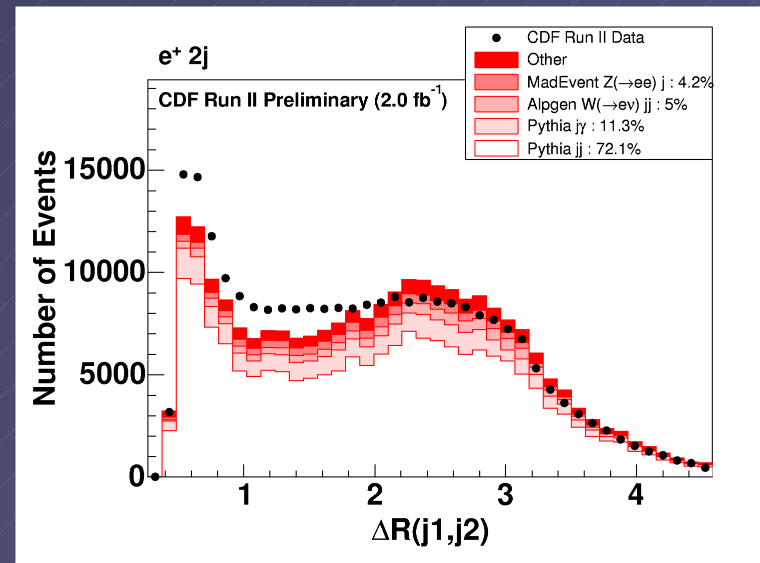


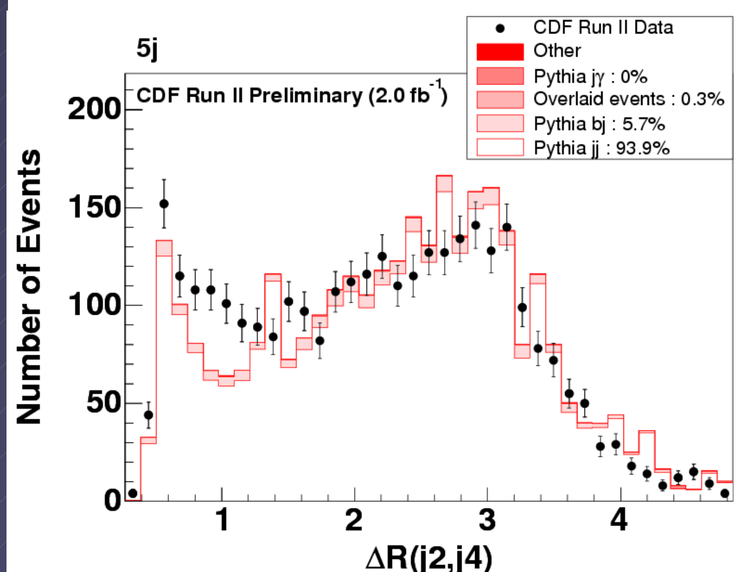
This analysis brought this issue ("3 jet effect") to attention and is currently being investigated by experimental and theoretical colleagues.

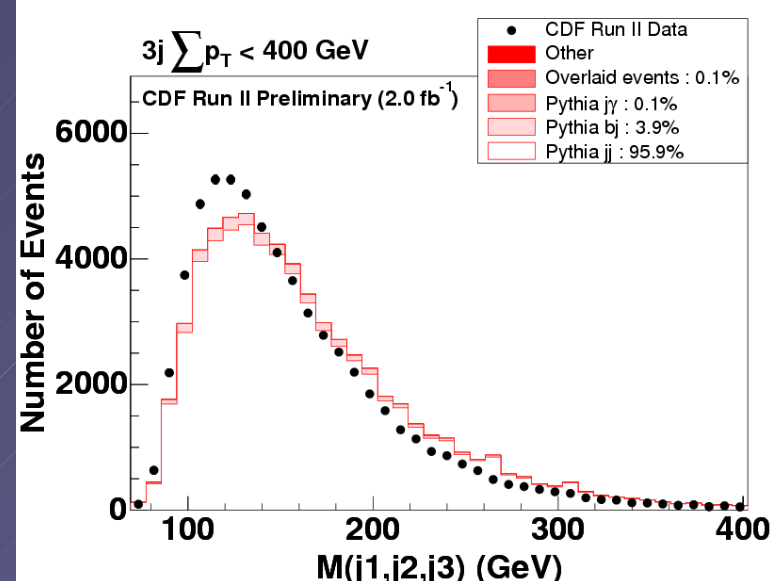
This is a major limiting factor in our ability to resolve mass resonances in multijet final states.

3 jet effect



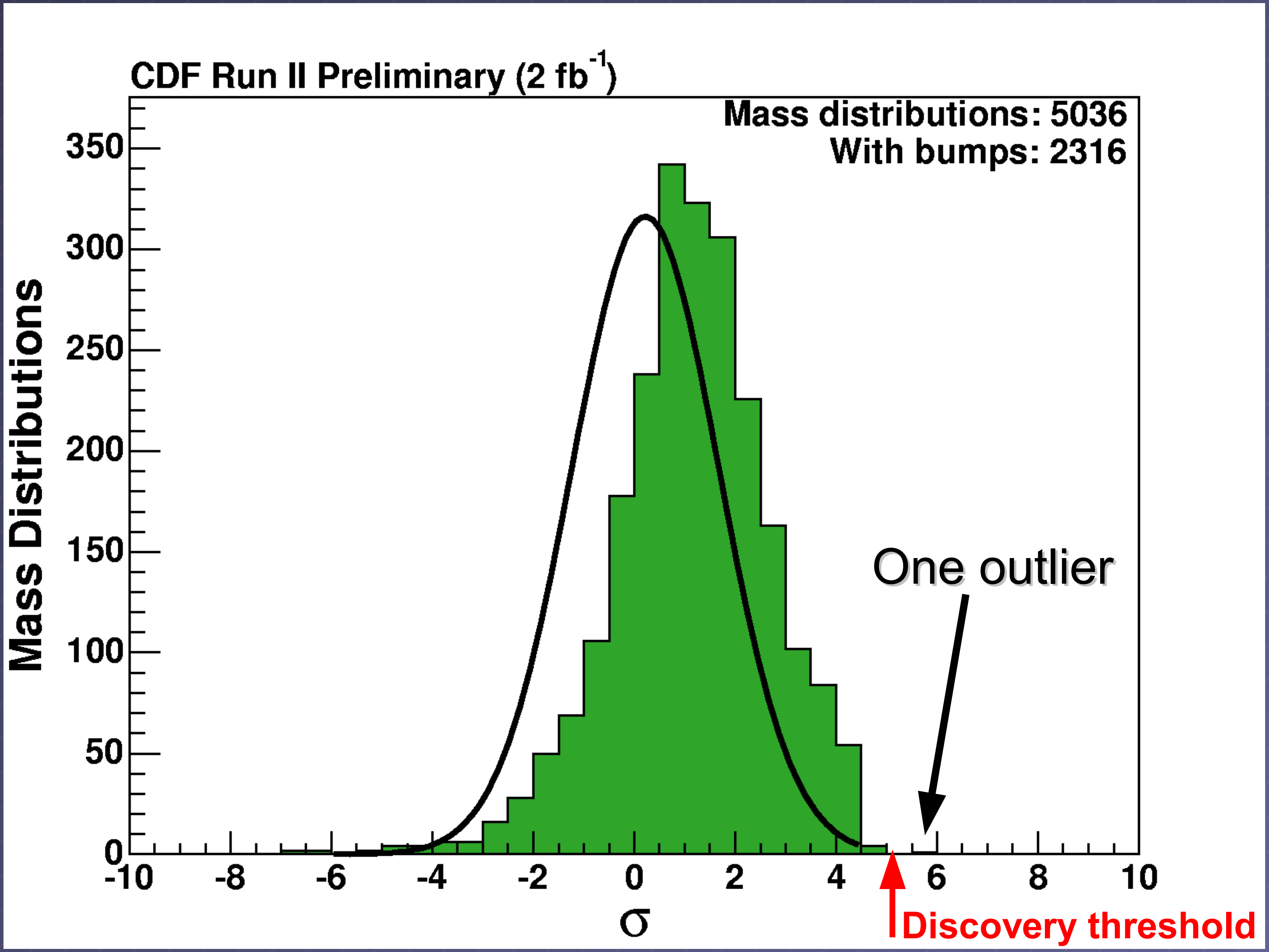




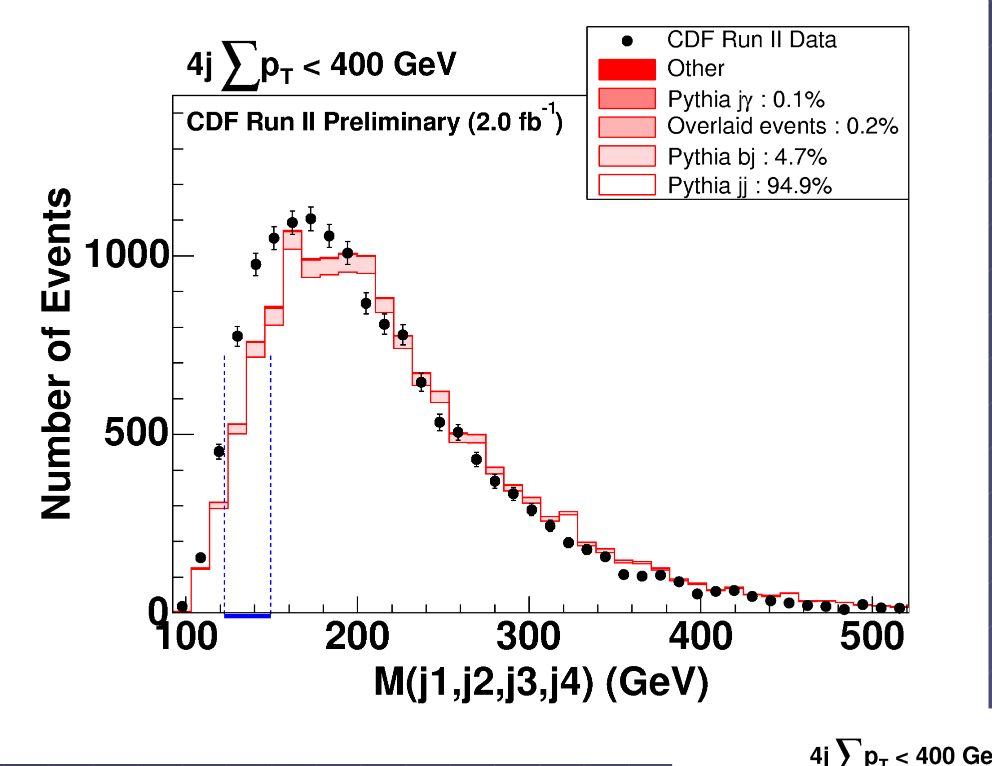


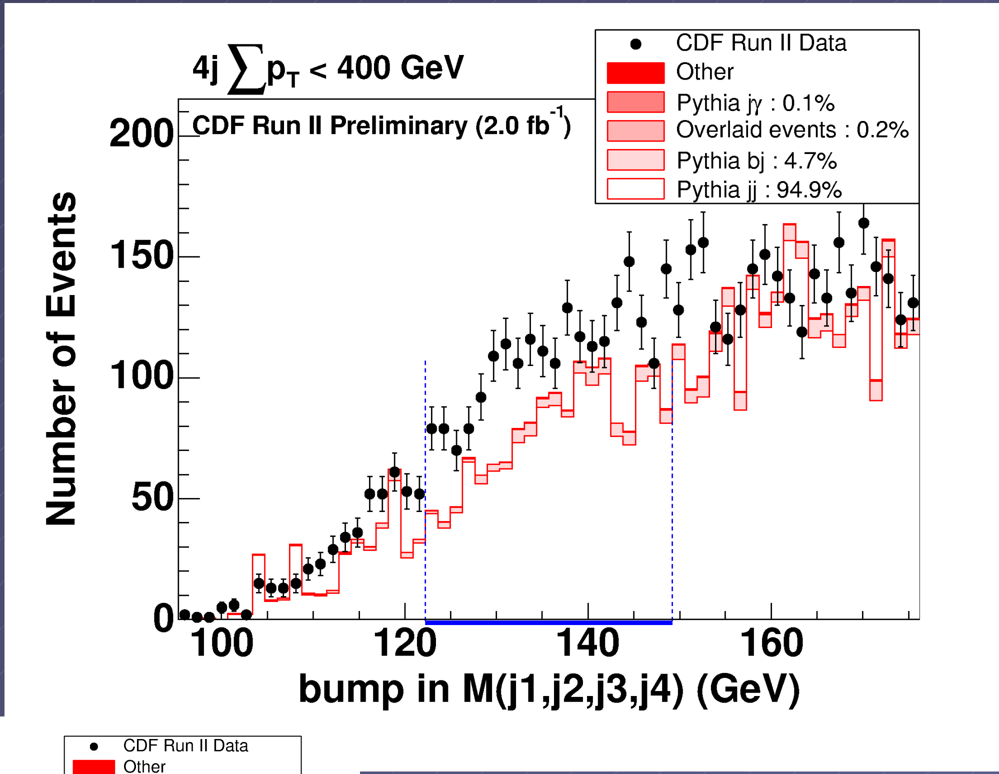
Conclusion: No discrepancies to motivate a new physics claim

Summary of Mass Bumps

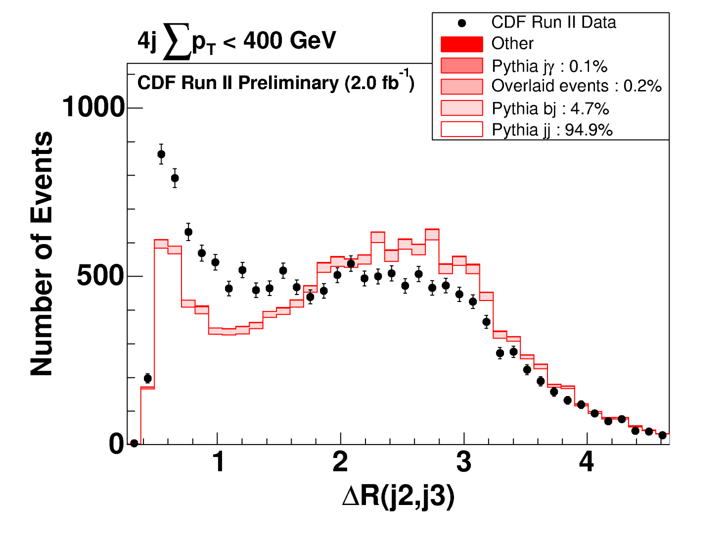


The outlier





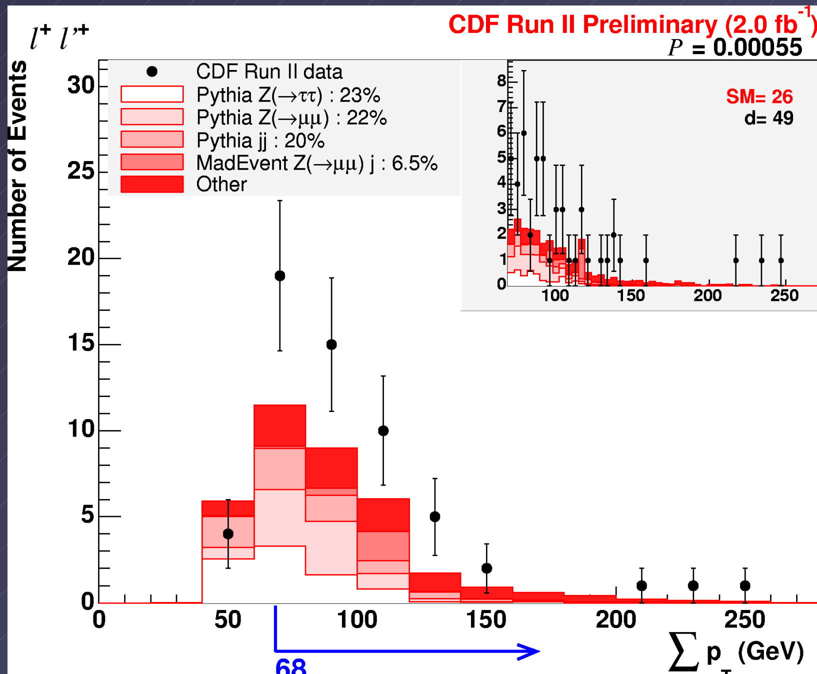
4.1 sigma bump after trials factor



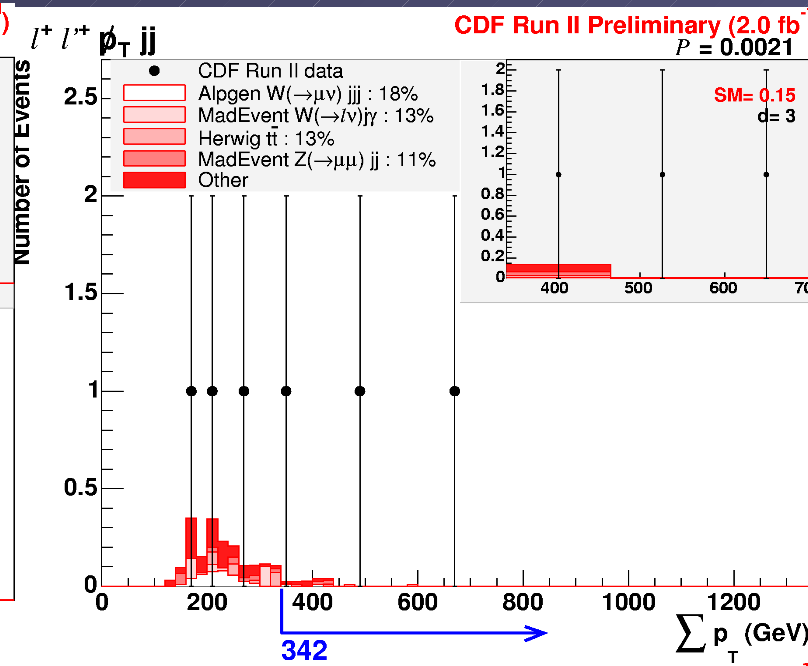
No new physics interpretation. "3-jet" effect again!!!

Sleuth Results

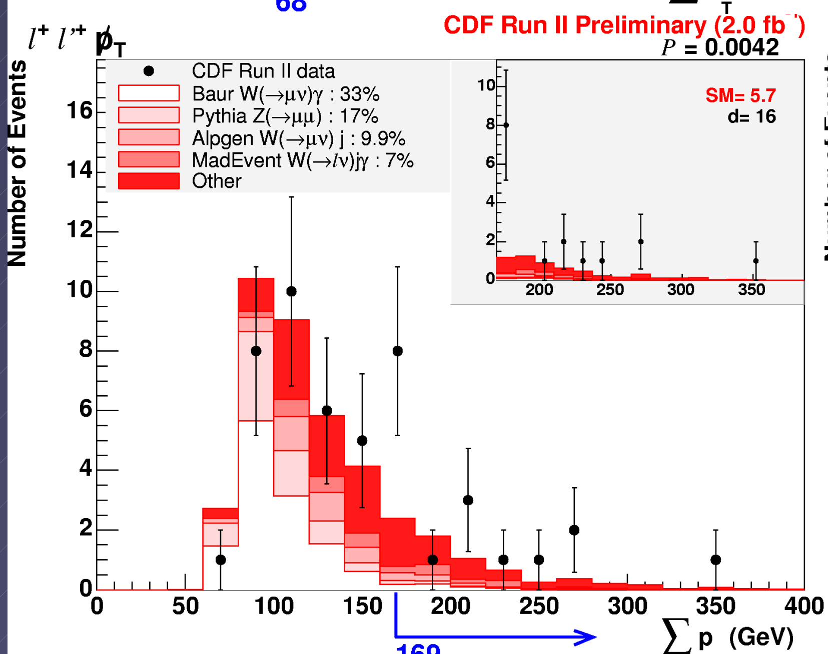
$e^{\pm}\mu^{\pm}$



$e^{\pm}\mu^{\pm} \not{E}_T\ jj$

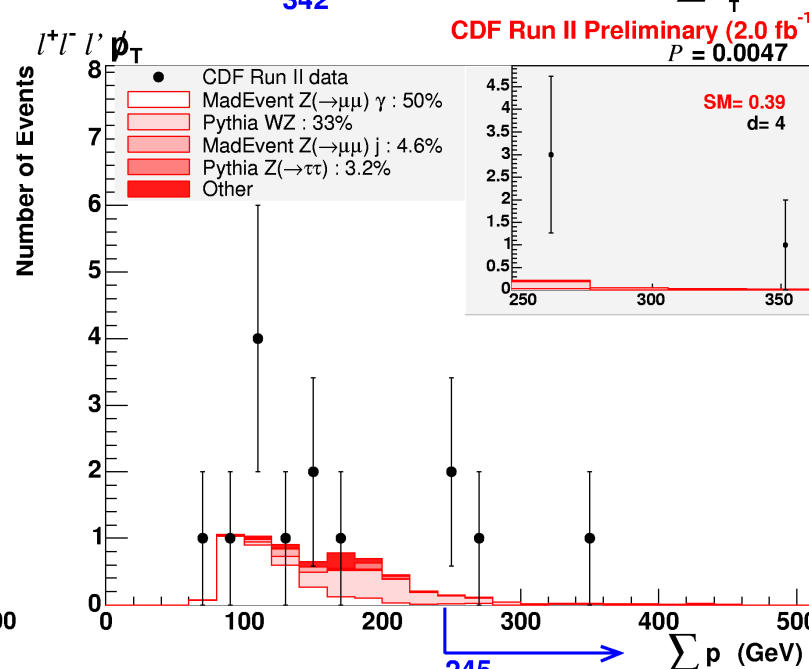


$e^{\pm}\mu^{\pm} \not{E}_T$



$e^{+}e^{-}\mu^{\pm} \not{E}_T$

$\mu^{+}\mu^{-}e^{\pm} \not{E}_T$



Sleuth Results Summary

CDF Run II Preliminary (2.0 fb^{-1})

SLEUTH Final State	$\mathcal{P}$
$\ell^+\ell'^+$	0.00055
$\ell^+\ell'^+\not{p}jj$	0.0021
$\ell^+\ell'^+\not{p}$	0.0042
$\ell^+\ell^-\ell'\not{p}$	0.0047
$\ell^+\tau^+\not{p}$	0.0065

The most discrepant Sleuth final state has a probability of 8% after accounting for trials factor

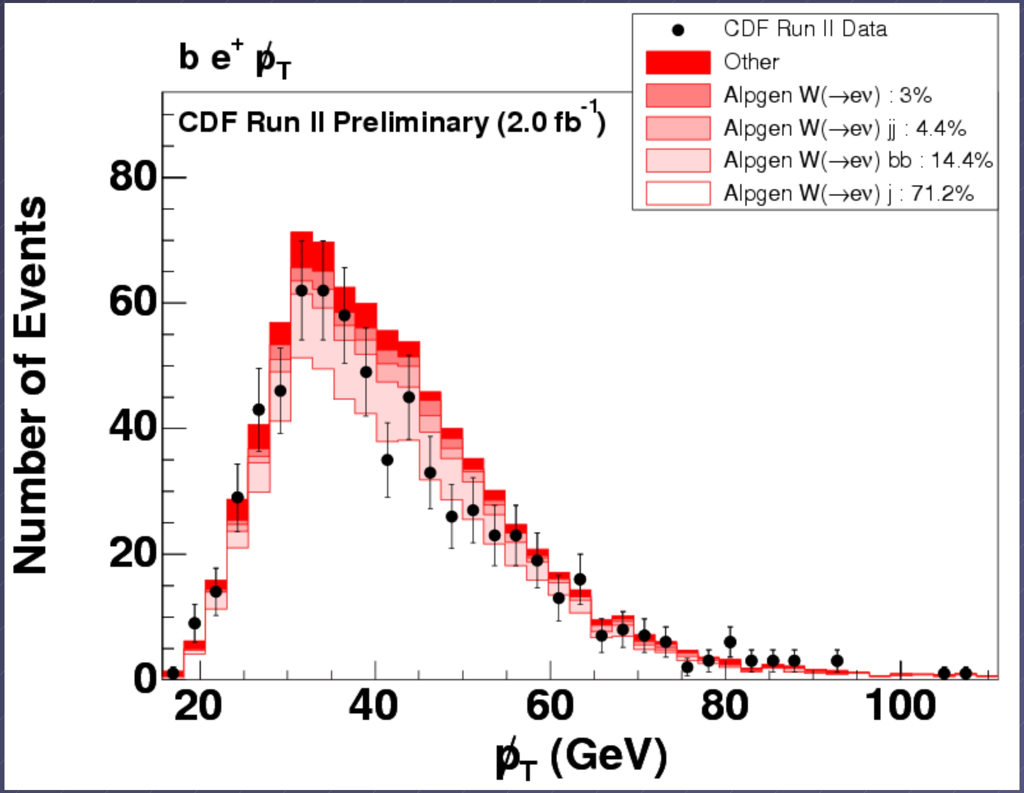
Conclusion

- Completed the global search for new physics in $2fb^{-1}$ at CDF
- This search represents one of the most encompassing tests of the Standard Model at the energy frontier.
- This analysis finds...
  - No significant final state population discrepancies.
  - No shape discrepancies motivating new physics
  - No bumps motivating new physics
  - No statistically significant Sleuth Σp_T excess.
- The search continues...

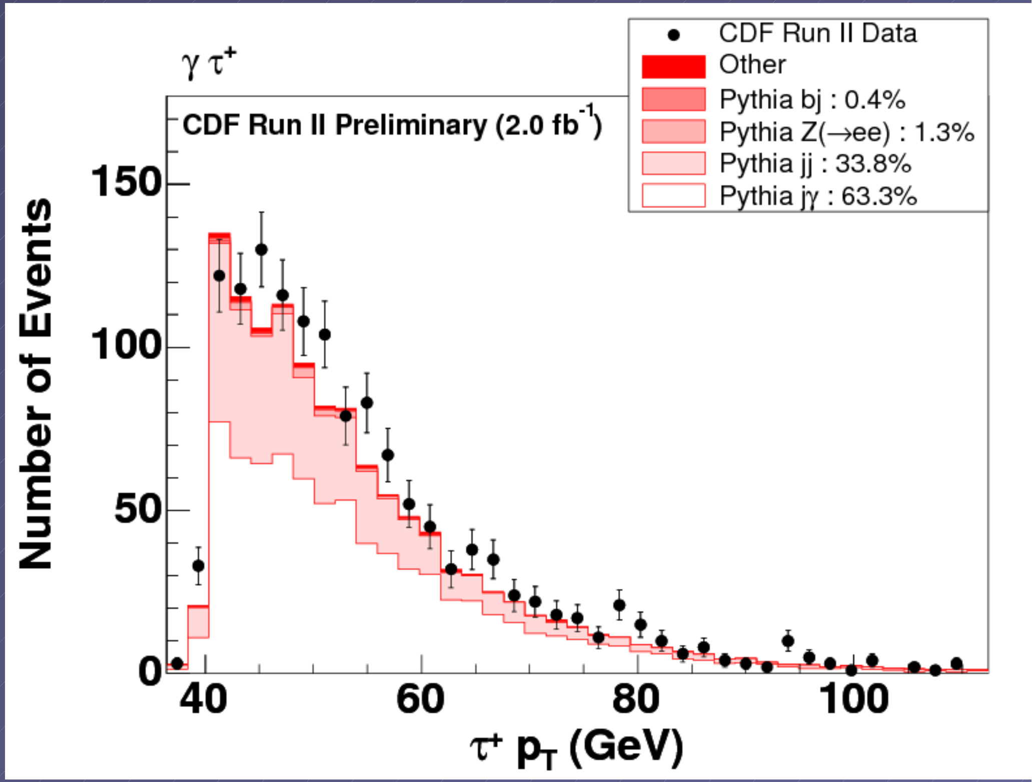
BACKUP

A few example distributions

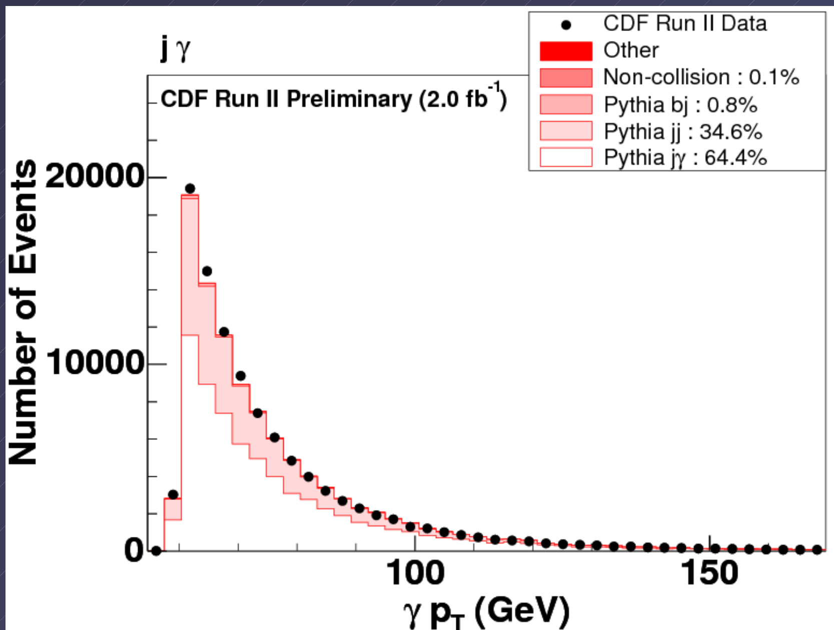
From
Most significant deficit

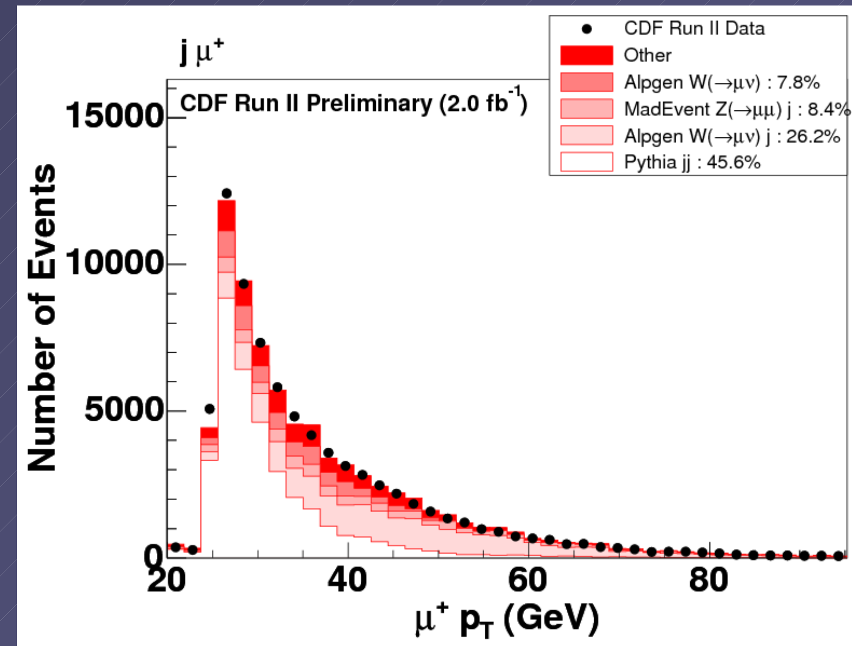


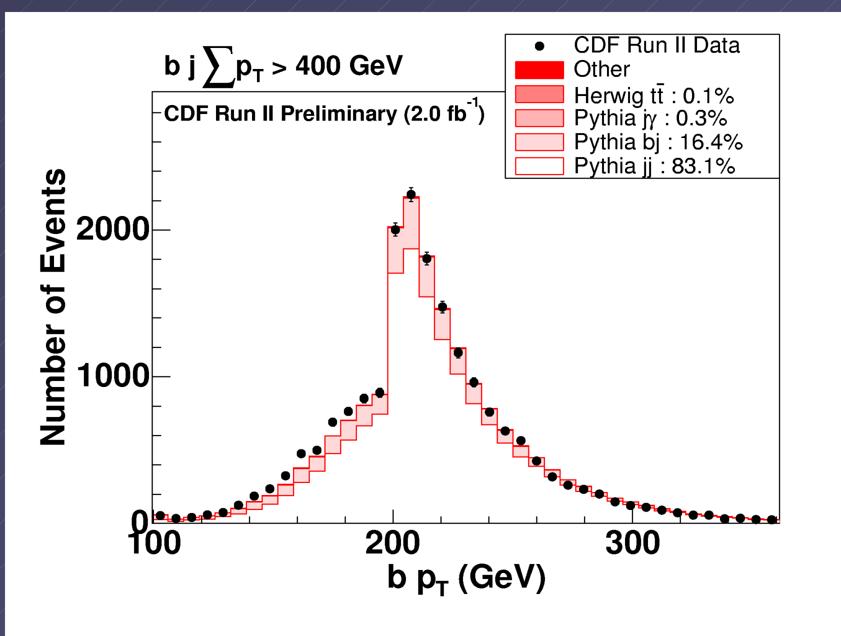
From
Most significant excess

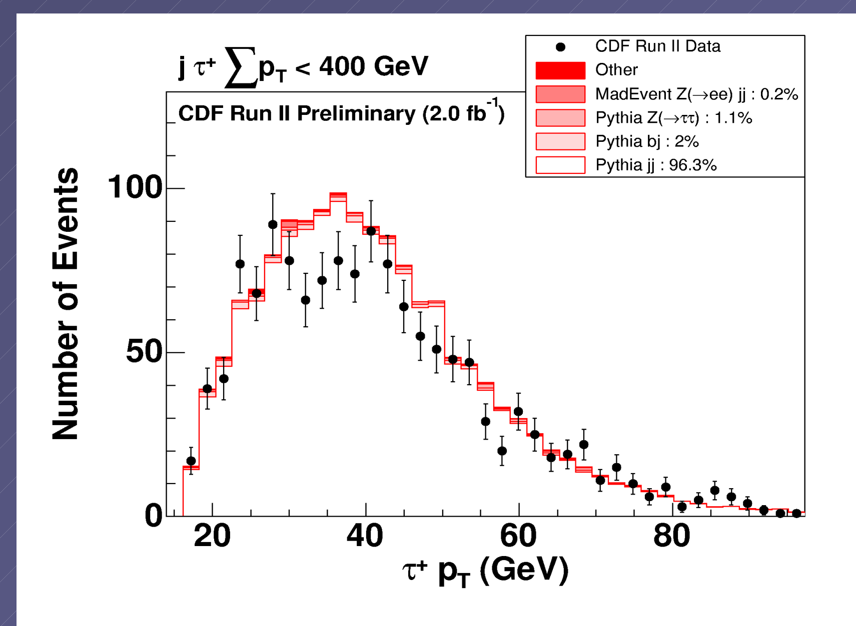


Some typical distributions that constrain correction factors



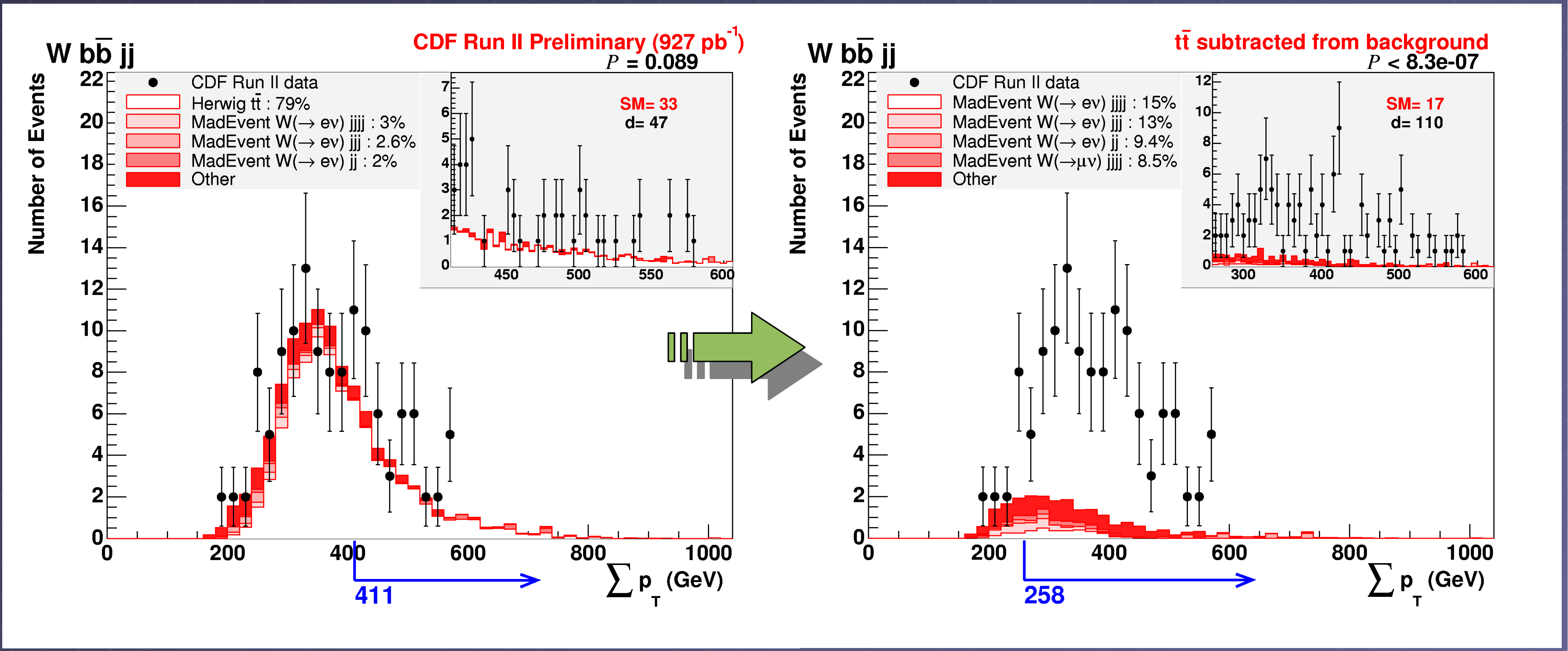






Sensitivity: Top Discovery?

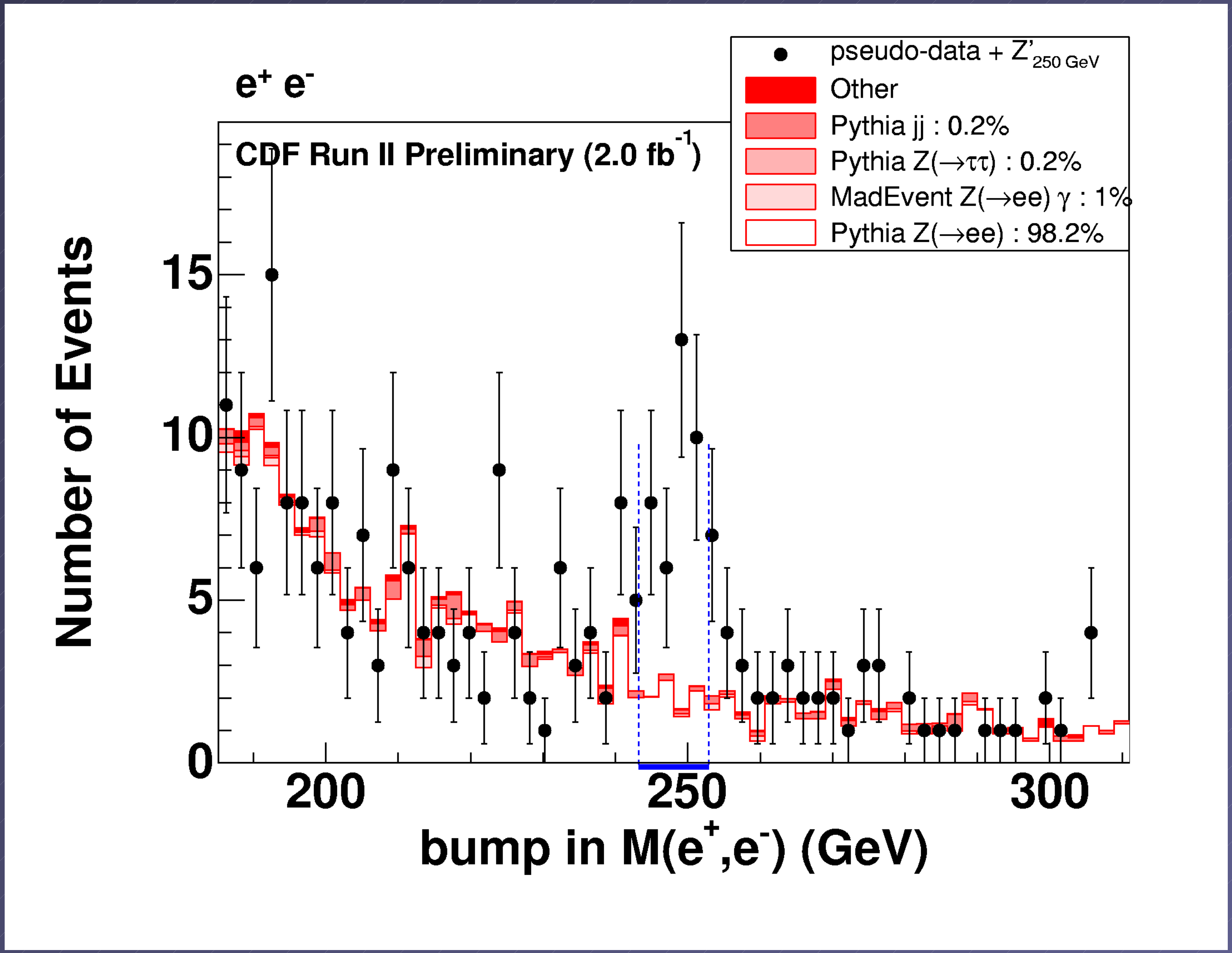
Remove top quark from Standard Model, refit correction factors, search!



Easily finding top in 1 fb^{-1}

Approximate Luminosity Needed ~ O (Run1 Discovery)

Sensitivity: Z' mass bump ?



$Z'_{250} \rightarrow$ charged leptons

5σ discovery if $\sigma \times BR \approx 0.325$ pb.

Global Fit

$$\chi^2(\vec{s}) = \left(\sum_{k \in \text{bins}} \chi^2_k(\vec{s}) \right) + \chi^2_{\text{constraints}}(\vec{s})$$

$$\chi^2_k(\vec{s}) = \frac{(\text{Data}[k] - \text{SM}[k])^2}{\delta\text{SM}[k]^2 + \sqrt{\text{SM}[k]}^2}$$

Correction Factors

Code	Category	Explanation	Value	Error	Error(%
0001	luminosity	CDF integrated luminosity	1990	50	2.6
0002	k-factor	cosmic_ph	0.81	0.05	6.1
0003	k-factor	cosmic_j	0.192	0.006	3.1
0004	k-factor	$1\gamma1j$ photon+jet(s)	0.91	0.04	4.4
0005	k-factor	$1\gamma2j$	1.27	0.05	3.9
0006	k-factor	$1\gamma3j$	1.58	0.08	5.1
0007	k-factor	$1\gamma4j+$	1.99	0.16	8.1
0008	k-factor	$2\gamma0j$ diphoton(+jets)	1.64	0.08	4.9
0009	k-factor	$2\gamma1j$	2.96	0.17	5.7
0010	k-factor	$2\gamma2j+$	1.2	0.09	7.5
0011	k-factor	W0j W (+jets)	1.37	0.03	2.3
0012	k-factor	W1j	1.32	0.03	2.3
0013	k-factor	W2j	2	0.05	2.5
0014	k-factor	W3j+	2.08	0.09	4.3
0015	k-factor	Z0j Z (+jets)	1.391	0.028	2.0
0016	k-factor	Z1j	1.23	0.04	3.2
0017	k-factor	Z2j+	1.02	0.04	3.9
0018	k-factor	2j $\hat{p}_T$<150 dijet	1.005	0.027	2.7
0019	k-factor	2j 150<$\hat{p}_T$	1.34	0.03	2.2
0020	k-factor	3j $\hat{p}_T$<150 multijet	0.945	0.025	2.6
0021	k-factor	3j 150<$\hat{p}_T$	1.48	0.04	2.7
0022	k-factor	4j $\hat{p}_T$<150	1.06	0.03	2.8
0023	k-factor	4j 150<$\hat{p}_T$	1.93	0.06	3.1
0024	k-factor	5j low	1.34	0.05	3.7
0025	k-factor	1b2j 150<$\hat{p}_T$	2.24	0.11	4.9
0026	k-factor	1b3j 150<$\hat{p}_T$	3.06	0.15	4.9
0027	misId	p(e→e) central	0.978	0.006	0.6
0028	misId	p(e→e) plug	0.965	0.007	0.7
0029	misId	p($\mu\to\mu$) CMUP+CMX	0.888	0.007	0.8
0030	misId	p($\gamma\to\gamma$) central	0.936	0.018	1.9
0031	misId	p($\gamma\to\gamma$) plug	0.86	0.016	1.9
0032	misId	p(b→b) central	0.971	0.021	2.2
0033	misId	p($\gamma\to$e) plug	0.06	0.003	5.0
0034	misId	p(q→e) central	7.07×10^{-5}	1.9×10^{-6}	2.7
0035	misId	p(q→e) plug	0.000785	1.2×10^{-5}	1.5
0036	misId	p(q→μ)	1.22×10^{-5}	6×10^{-7}	4.9
0037	misId	p(b→μ)	3.2×10^{-5}	1.1×10^{-5}	34.0
0038	misId	p(j→b) 25<p_T	0.0183	0.0002	1.1
0039	misId	p(q→τ)	0.0053	0.0001	1.9
0040	misId	p(q→γ) central	0.000269	1.4×10^{-5}	5.2
0041	misId	p(q→γ) plug	0.00048	6×10^{-5}	12.4
0042	trigger	p(e→trig) plug, p_T>25	0.838	0.007	0.8
0043	trigger	p(μ→trig) CMUP+CMX, p_T>25	0.92	0.004	0.4

Sleuth Algorithm

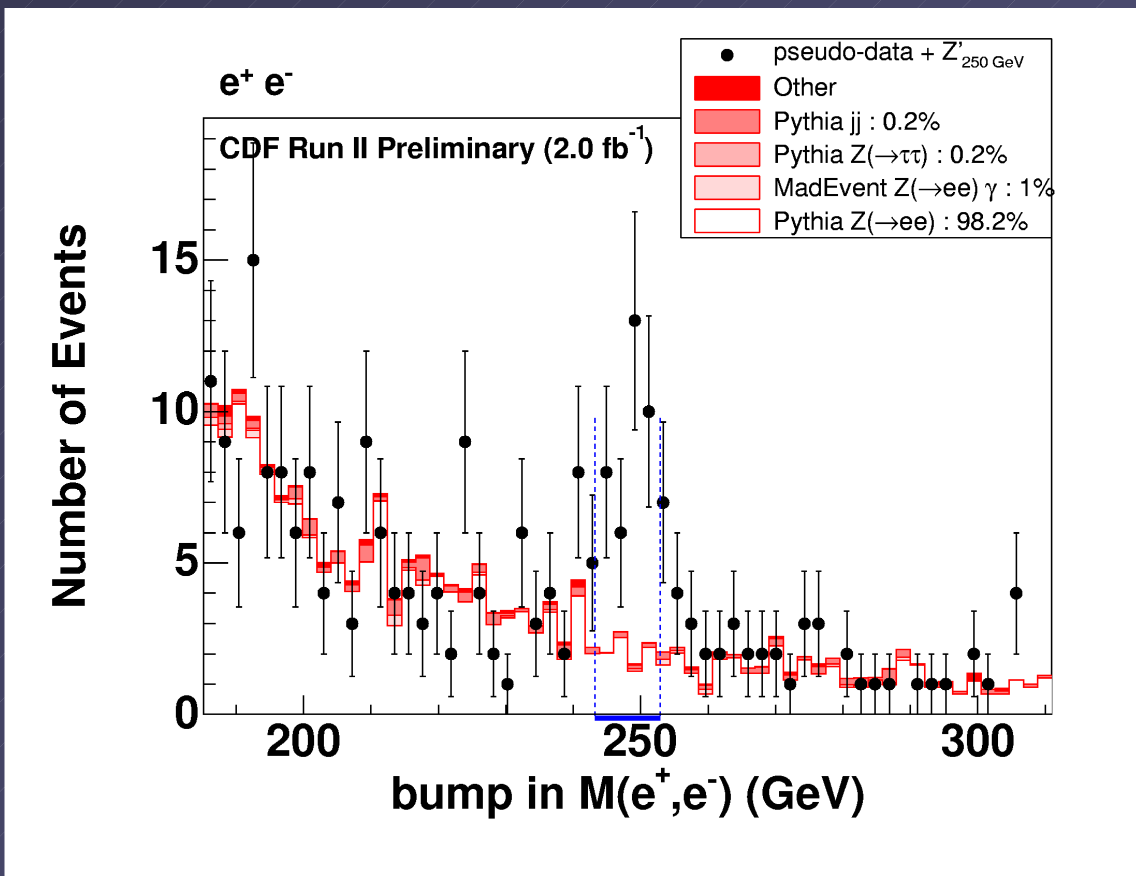
Sleuth variable:

$$\sum p_T \equiv \sum_i |\vec{p}_i| + \left|\overrightarrow{\mathrm{uncl}}\right| + \left|\vec{\not{p}}\right|,$$

- Scan the sumPt spectrum in all final states and find the region with the most significant excess of data over SM.
- Perform pseudo-experiments to determine the probability that a statistical fluctuation of the background would yield an excess as significant as the one observed
- Takes into account the trials factor for looking at many places
- Discovery level significance set at 0.001 = 5σ effect

Method

Caution: This is NOT real data!



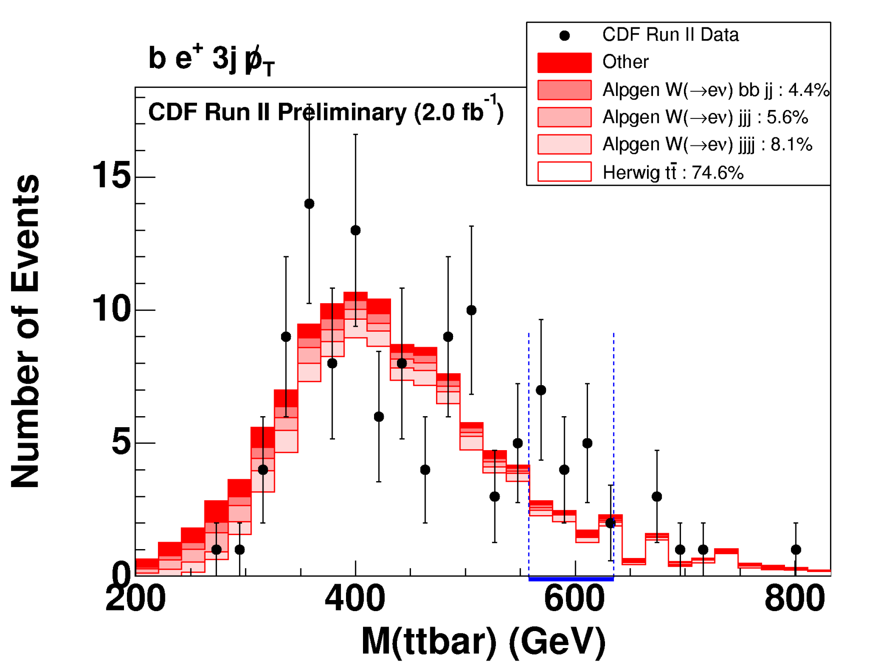
Scan all mass spectra with a window.

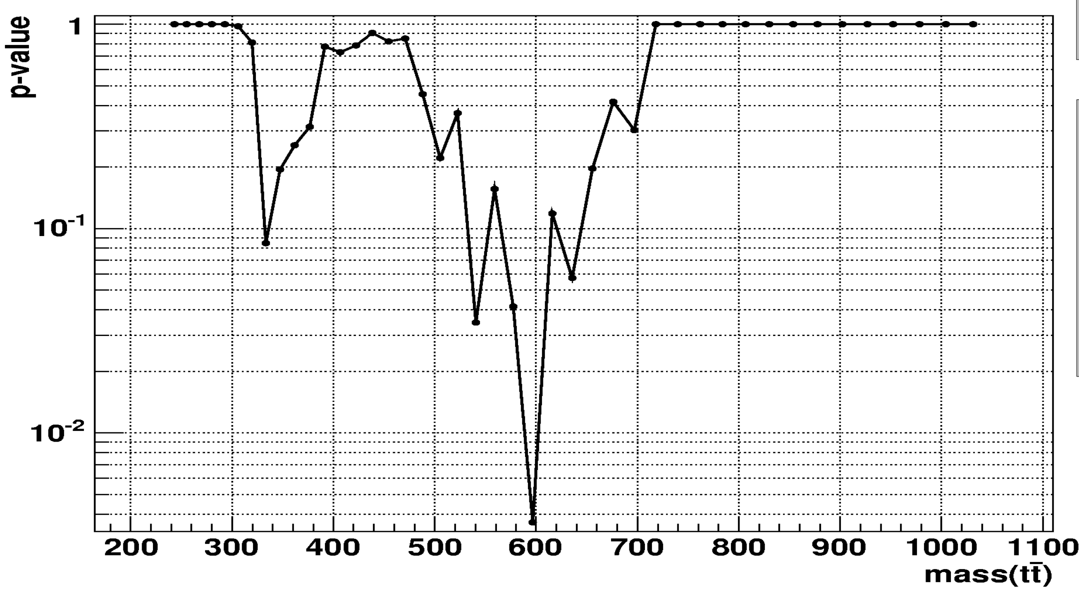
Window size follows mass resolution.

$$m = \sqrt{\left(\sum_i E_i\right)^2 - \left(\sum_i \vec{p}_i\right)^2} \Rightarrow \Delta m$$

- Consider bumps with ≥ 5 data events.
- Sidebands have to agree more than center, and not be too discrepant (5σ).

Statistical Significance





Each bump has a p-value

$$\sum_{n=d}^{\infty} \frac{b^n}{n!} e^{-b}$$

Most interesting bump: p-val_{min}

Use pseudo-data to find

P_a = The probability that a p-val ≤ p-val_{min} would appear by coincidence.

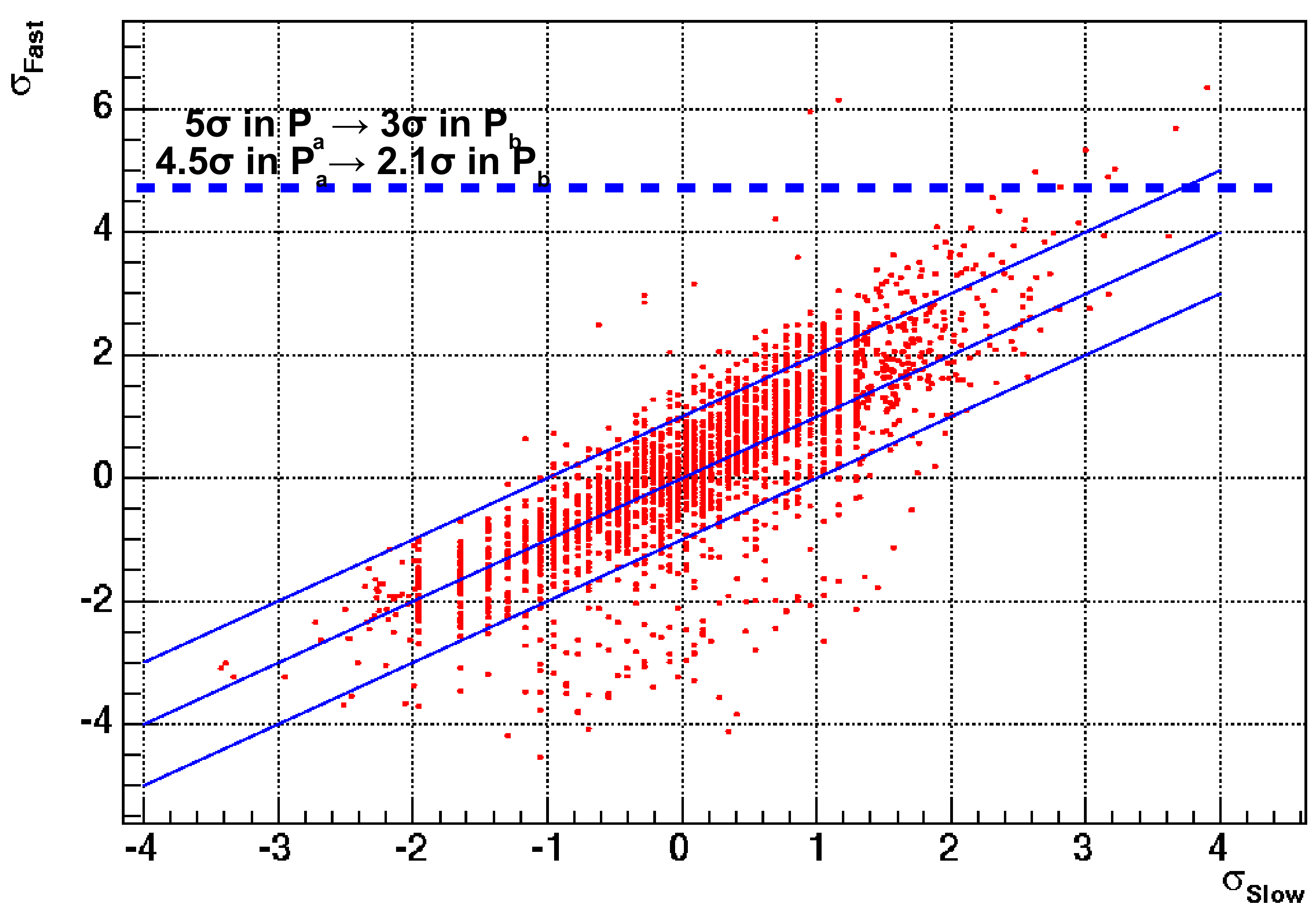
$P_b = 1 - (1-P_a)^{\text{5000 distributions}}$

= probability at least one mass would have such a small P_a by coincidence.

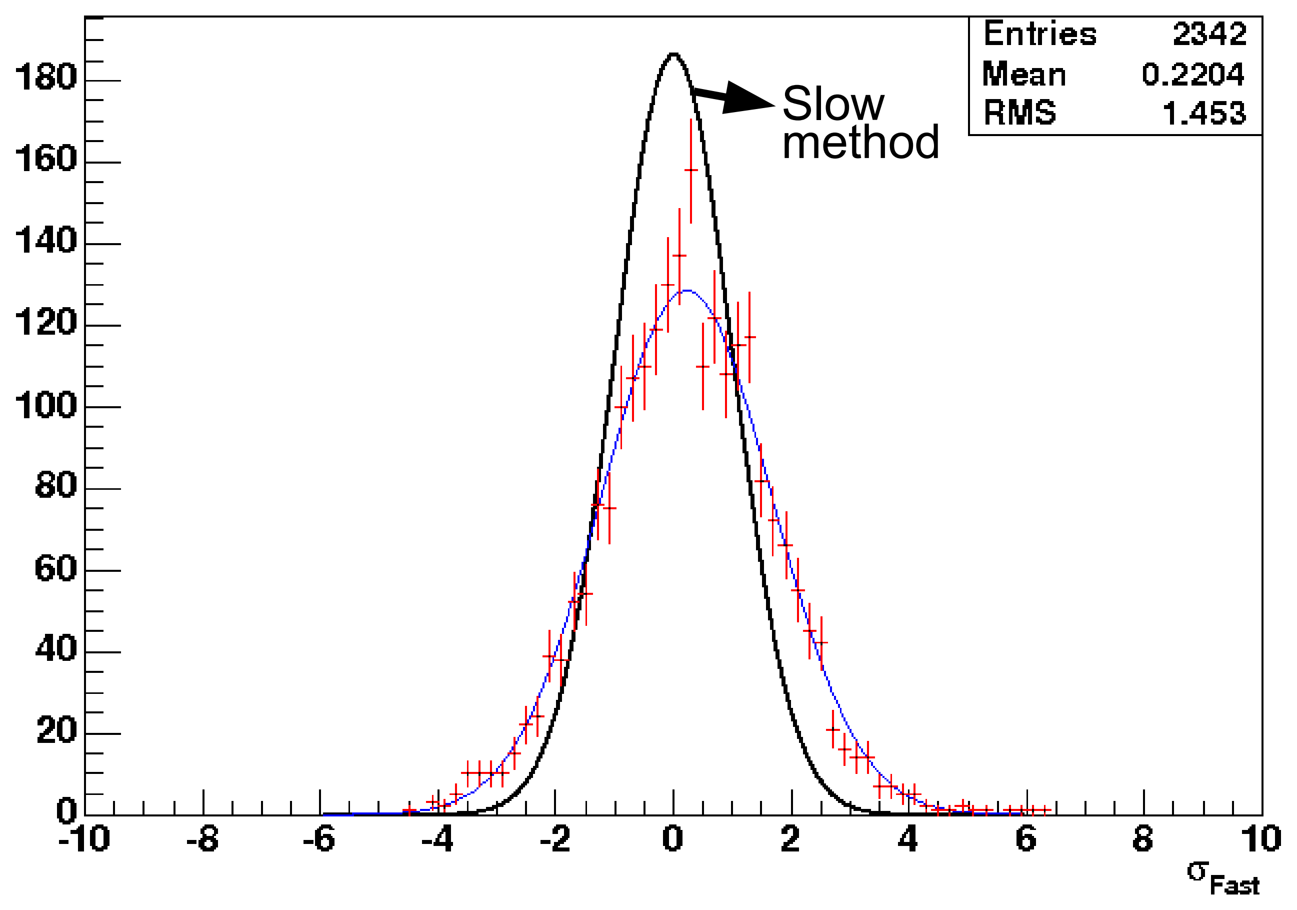
Discovery threshold:

$P_b = 3\sigma \leftrightarrow P_a = 5\sigma$

Fast vs Slow method to estimate P_a

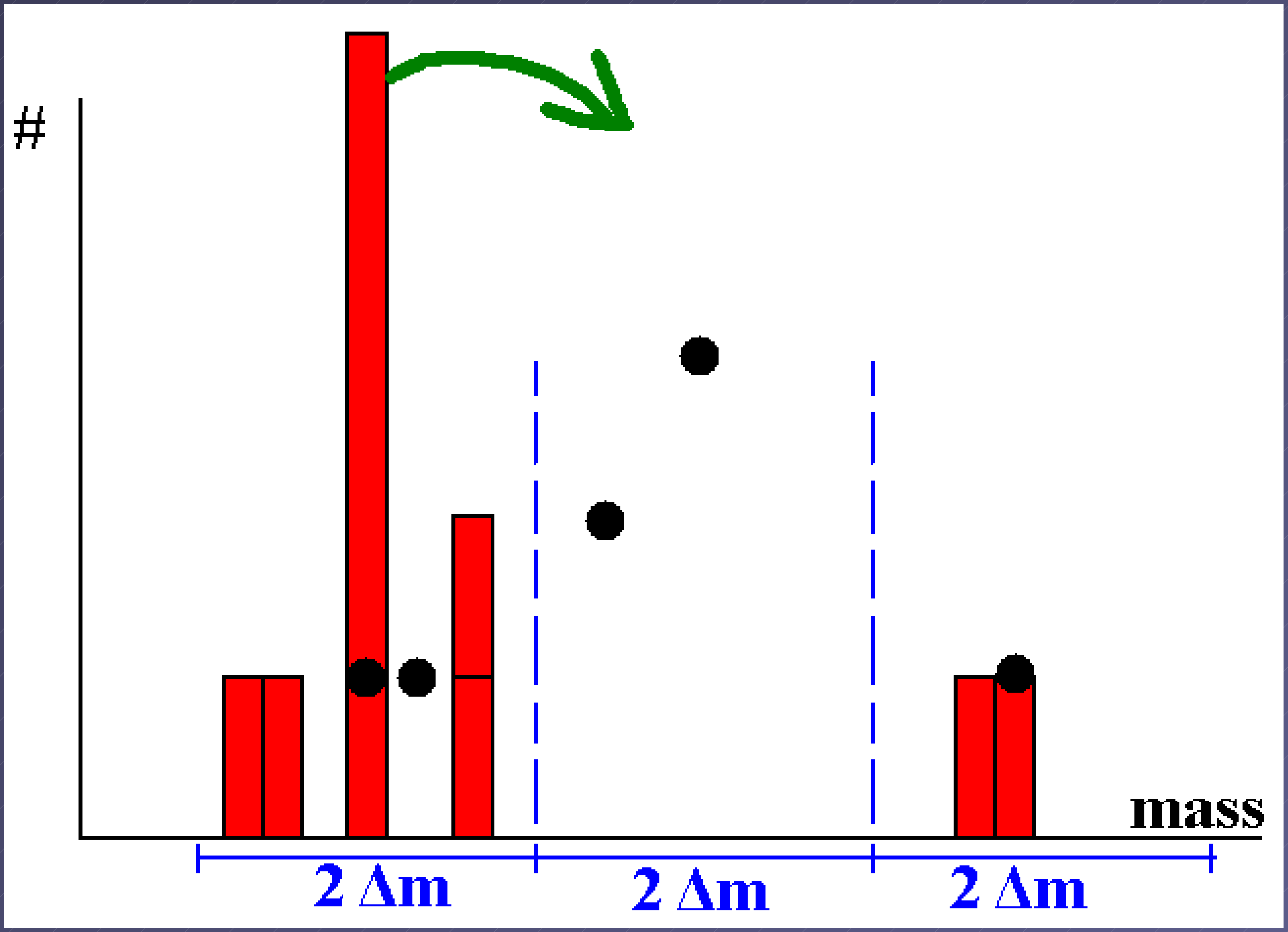


Expected P_a



Entries 2342
Mean 0.2204
RMS 1.453
Slow method
180
160
140
120
100
80
60
40
20
0
-10
-8
-6
-4
-2
0
2
4
6
8
10
σ_{Fast}

The need for spike treatment



Potential for Improvement

- Search for wider resonances
- Combine leptons & jet multiplicities
- Dynamic optimization of window width
- Use of only data